PROCEEDINGS

OF THE

Iowa Academy of Sciences,

FOR 1893.

VOLUME I, PART IV.

DES MOINES:
G. H. RAGSDALE, STATE PRINTER.
1894.

PROCEEDINGS

OF THE

Iowa Academy of Sciences,

FOR 1893.

VOLUME 1, PART IV.

EDITED BY THE SECRETARY,
HERBERT OSBORN, AMES, IOWA.

PRINTED BY ORDER OF THE GENERAL ASSEMBLY.

DES MOINES:
G. H RAGSDALE, STATE PRINTER.
1894.

OFFICERS OF THE ACADEMY.

1893.

President—L. H. PAMMEL.
First Vice President—C. O. BATES.
Second Vice President—A. A. VEBLEN.
Secretary-Treasurer—HERBERT OSBORN.

EXECUTIVE COMMITTEE.

Ex-Officio—L. H. PAMMEL, C. O. BATES, A. A. VEBLEN, H. OSBORN.
Elective—S. CALVIN, F. M. WITTER, H. W. NORRIS.

1894.

President—L. W. ANDREWS.
First Vice President—H. W. NORRIS.
Second Vice President—C. R. KEYES.
Secretary-Treasurer—HERBERT OSBORN.

EXECUTIVE COMMITTEE.

Ex-Officio—L. W. ANDREWS, H. W. NORRIS, C. R. KEYES, H. OSBORN.
Elective—C. C. NUTTING, M. F. AREY, W. S. HENDRIXSON.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ANDREWS, L. W.	State University, Iowa City
AREY, M. F.	State Normal School, Cedar Falls
BAIN, H. F.	Geological Survey, Des Moines
BARRIS, W. H.	Davenport, Iowa
BATES, C. O.	Coe College, Cedar Rapids
BEACH, ALICE M.	Agricultural College, Ames
BEAL, A. M.	Western College, Toledo
BENNETT, A. A.	Agricultural College, Ames
BEYER, S. W.	Agricultural College, Ames
BISSELL, G. W.	Agricultural College, Ames
CALVIN, S.	State University, Iowa City
CHAPPEL, GEO. M.	Signal Service, Des Moines
CONRAD, A. H.	Parsons College, Fairfield
CURTISS, C. F.	Agricultural College, Ames
DREW, GILMAN	High School, Oskaloosa
FRANKLIN, W. S.	Agricultural College, Ames
FULTZ, F. M	Burlington
GOSSARD, H. A.	Albion Seminary, Albion
HALL, T. P.	Tabor College, Tabor
HANSEN, N. E.	Agricultural College, Ames
HAZEN, E. H.	Des Moines
HENDRIXSON, W. S.	Iowa College, Grinnell
HOLWAY, E. W. D.	Decorah
HOWE, MINNIE	High School, Des Moines
HOUSER, G. L.	State University, Iowa City
JACKSON, J. A.	Des Moines
JAMESON, C. D.	State University, Iowa City
KEYES, C. R.	Geological Survey, Des Moines
LEONARD, A. G.	Geological Survey, Dubuque
LONSDALE, E. H.	Geological Survey, Des Moines
MALLY, C. W.	Des Moines
MARSTON, A.	Agricultural College, Ames
MCBRIDE, T. H.	State University, Iowa City
NEWTON, G. W.	Cornell College, Mt. Vernon
NILES, W. B.	Agricultural College, Ames
NORRIS, H. W.	Iowa College, Grinnell
NORTON, W. H.	Cornell College, Mt. Vernon
NUTTING, C. C.	State University, Iowa City
OSBORN, HERBERT	Agricultural College, Ames
PAGE, A. C.	State Normal School, Cedar Falls
PAMMEL, L. H.	Agricultural College, Ames
PATRICK, G. E.	Agricultural College, Ames

REPPERT, F. .... Muscatine
ROSS, L. S. .... Drake University, Des Moines
SAGE, J. R. .... State Weather and Crop Service, Des Moines
SCHAEFFER, C. A. .... State University, Iowa City
SCHLABACH, CARL .... High School, Clinton
SHIMEK, B. .... State University, Iowa City
SIRRINE, F. A. .... Agricultural College, Ames
SPENCER, A. C. .... Geological Survey, Des Moines
STALKER, M. .... Agricultural College, Ames
STANTON, E. W. .... Agricultural College, Ames
STEWART, F. C. .... Agricultural College, Ames
STONER, C. E. .... Des Moines
STOOKEY, STEPHEN .... Coe College, Cedar Rapids
TILTON, J. L. .... Simpson College, Indianola
VEBLEN, A. A. .... State University, Iowa City
WACHSMUTH, CHAS. .... Burlington, Iowa
WALKER, PERCY H. .... State University, Iowa City
WELD, L. G. .... State University, Iowa City
WINDLE, WM. S. .... Penn College, Oskaloosa
WITTER, F. M. .... Muscatine

ASSOCIATE MEMBERS.

ANKENY, MISS NELLIE W. .... Ottumwa
BEARDSHEAR, W. M. .... Agricultural College, Ames
BROWN, EUGENE .... Mason City
HADLEY, S. M. .... Oskaloosa
MILLER, G. P. .... Des Moines
MILLS, J. S. .... Western College, Toledo
OSBORN, B. F. .... Rippey
ROLFS, J. A. .... LeClaire
YOUTZ, L. A. .... Simpson College, Indianola

CORRESPONDING MEMBERS.

BARBOUR, E. H. .... State University, Lincoln, Nebraska
BESSEY, C. E. .... State University, Lincoln, Nebraska
BRUNER, H. L. .... Irvington, Indiana
CALL, R. E. .... Louisville, Kentucky
COLTON, G. H. .... Virginia City, Montana
CROZIER, A. A. .... Ann Arbor, Michigan
DAVIS, FLOYD .... Socorro, New Mexico
GILLETTE, C. P. .... Agricultural College, Ft. Collins, Colorado
HALSTED, B. D. .... New Brunswick, New Jersey
HAWORTH, ERASMUS .... State University, Lawrence, Kansas
HITCHCOCK, A. S. .... Agricultural College, Manhattan, Kansas
MALLY, F. W. .... Dickerson, Texas
McGEE, W. J. .... United States Geological Survey, Washington, D. C.
MEEK, S. E. .... State University, Fayetteville, Arkansas
PARKER H. W. .... New York City, New York
ROLFS, P. H. .... Agricultural College, Lake City, Florida
TODD, J. E. .... State University, Vermilion, South Dakota
WINSLOW, ARTHUR .... Geological Survey, Jefferson City, Missouri

PROCEEDINGS

OF THE

EIGHTH ANNUAL MEETING

OF THE

IOWA ACADEMY OF SCIENCES.

The eighth annual session of the Iowa Academy of Sciences was held in Des Moines, December 26 and 27, 1893.

The following papers, read in full or by title, were, by action of the Executive Committee, referred to the Secretary for publication:

L. W. ANDREWS—On the Assumption of a Special "Nascent State." Some Peculiarities of Solutions of Sulpho-cyanate.

A. A. BENNETT—Work in the Chemical Laboratory of the Iowa Agricultural College.

W. S. HENDRIXSON—The Electrolysis of Silver: Some Laboratory Apparatus.

G. W. BISSELL—Experimental Engineering at the Iowa Agricultural College.

S. CALVIN—On the Geological Position of *Benettites dacotensis* Macbride, with Observations on the Stratigraphy of the Region in which the Species was Discovered.

WM. H. NORTON—Some Preliminary Notes on the Lower Devonian Strata of Iowa.

C. R. KEYES—Relations of the Cretaceous Formations in Northwestern Iowa. Derivation of the Unione Fauna of the Northwest. Process of Formation of Certain Quartzites.

J. L. TILTON—Origin of the Present Drainage System of Warren County

H. FOSTER BAIN—Structure of the Mystic Coal Basin. The Deep Well at Sigourney.

E. H. LONSDALE—Southern Extension of the Cretaceous in Iowa. Topography of the Granite and Porphyry Areas in Missouri.

A. G. LEONARD—Zinc Deposits in Northeastern Iowa. Satin Spar from Dubuque.

A. C. SPENCER—Occurrence in Iowa of Fossiliferous Concretions Similar to those of Mazon Creek.

F. M. FULTZ—Evidences of Disturbances During the Deposition of the Burlington Limestones.

A. J. JONES—The Coal Measures of Poweshiek County. On the Occurrence of *Cardiocarpus* in Iowa.

T. H. MCBRIDE—Notes on the North American Cycads. The Distribution of *Rhus typhina*.

L. H. PAMMEL—Presidential Address—Bacteria, Their Relation to Modern Medicine, the Arts and Industries. Powdery Mildew of the Apple. Further notes on *Cladosporium carpophilum*.

MARY ALICE NICHOLS—Observations on the Pollination of some of the *Compositæ*.

B FINK—Some Additions to the Flora of Iowa.

H. W. NORRIS—The Paraffine Method Applied to the Study of the Embryology of the flowering Plants. The Development of the Auditory Vesicle in *Necturus*. An instance of the Persistence of the Ductus Venosus in the Domestic Cat.

B. SHIMEK—Additional Notes on Iowa Mollusca. Variations in the *Succinidæ* of the Loess.

WM. S. WINDLE—Work at the Johns Hopkins Marine Biological Laboratory.

C. C. NUTTING—The Vascular Supply of the Teeth of the Domestic Cat. The Homology of the Inca Bone. An Informal Report on the Practicability of Dredging in Deep Water Without the Use of Steam.

HERBERT OSBORN—On the Distribution of Certain Hemiptera. Laboratory Notes in Zoology.

ALICE M. BEACH—Additions to the Known Species of Iowa *Ichneumonidæ*.

F. A. SIRRINE—A New Species of *Pemphigus* Occurring on Thorn.

C. W. MALLY—Hackberry *Psyllidæ* found at Ames, Iowa.

The following resolution was adopted in business session:

WHEREAS, The State has begun the good work of a Geological Survey of the State, a much needed investigation, and

WHEREAS, This work has been prosecuted for two years with vigor and success; therefore, be it

Resolved, That we, the Academy of Sciences, do most heartily commend the Geological Survey to the liberality of the General Assembly, with the hope that the Survey may receive all liberal encouragement and the support of such appropriations as may enable it to carry forward the various lines of its most excellent work.

A resolution was also passed and a committee appointed with reference to securing a better representation of scientific works in our State library and in other libraries of the State.

ON THE ASSUMPTION OF A SPECIAL "NASCENT STATE."

BY LAUNCELOT ANDREWS, PH. D.

The assumption frequently appears in chemical literature that elements at the moment of being set free from their compounds exhibit properties which the same elements do not ordinarily possess. This alleged specific condition is designated as the "nascent state" or *status nascendi*. The hypothesis of such a condition dates back to the time when the dualistic theory held sway and, so far as I am aware, has not been subjected to criticism in the light of modern views.

It is my purpose in the present paper to consider the following pertinent questions concerning this hypothesis:

First. Is it necessary to our understanding of any known facts?

Second. Does it offer a simpler explanation of any facts than can be given without its aid?

Third. Is it inconsistent with known facts?

Fourth. Can it be consistently applied to any class of phenomena without the aid of additional auxiliary assumptions?

One of the classes of chemical reactions which is most often explained by the assumption of a nascent state is that in which reduction is effected by metallic zinc in acid solutions or by sodium amalgam in aqueous neutral alkaline or acid solution or by other oxydizable metals. Here the metal is said to act upon the water or the acid, setting free hydrogen which in turn, by virtue of the peculiar properties it is supposed to possess in the nascent state, effects the reduction.

Thus the reducing of ferric chloride to ferrous chloride by zinc in acid solutions would be represented by the following two equations:

$$Zn+2H\,Cl=Zn\,Cl_2+H_2 \qquad [1$$

$$2H+2Fe\,Cl_3=2Fe\,Cl_2+2H\,Cl \qquad [2$$

The reduction of a copper sulphate solution would be represented thus:

$$H_2SO_4+Cu=Cu\,SO_4+2H \qquad [3$$

$$2H+Cu\,SO_4=Cu+H_2\,SO_4 \qquad [4$$

And in the same way the reduction of metallic Cu at the negative electrode during the electrolysis of a Cu SO_4 solution would be represented as *secondary* and due to the nascent hydrogen appearing there. In the familiar process of preparing sulphurous anhydride by the action of copper on concentrated hot sulphuric acid we find it assumed that hydrogen is first produced as in equation 3 and then in *statu nascendi* immediately reacts on the sulphuric acid,

$$Cu+H_2SO_4=Cu\,SO_4+H_2 \qquad [5$$
$$2H+H_2SO_4=2H_2O+SO_2 \qquad [6$$

forming water and sulphurous anhydride.

Many other cases might be cited of simple reactions in which it is considered necessary by some authors to employ the nascent hypothesis, but I shall, for the present, confine myself to these and in the light of the facts seek an answer to our four crucial questions. If we dispense with the hypothesis we must assume in each case a direct action of the metal on the salt; thus zinc and ferric chloride would give zinc chloride and ferrous chloride.

$$Zn+2Fe\,Cl_3=Zn\,Cl_2+2Fe\,Cl_2 \qquad [7$$

Zinc and copper sulphate would simply present a case of direct interchange of metals.

$$Zn+Cu\,SO_4=Zn\,SO_4+Cu \qquad [8$$

The reduction of copper by electrolysis would be primary not secondary.

$$Cu \xleftarrow{\text{To negative pole.}} Cu\,SO_4 \xrightarrow{\text{To positive pole.}} SO_3+O \qquad [9$$

This view in the latter case will not be seriously questioned by any student of the recent work of Arrhenius and Ostwald and their followers.

Lastly, we can simply represent the reduction of hot concentrated sulphuric acid as consisting in the first stage in an oxidation of the copper at the expense of the acid.

$$Cu+H_2SO_4=Cu\,O+\underbrace{H_2\,SO_3}_{H_2O\;SO_2} \qquad [10$$

The sulphurous acid becoming dehydrated of course at the high temperature of the reaction; and the copper oxide being soon converted into copper sulphate.

In the cases named it is clear that the nascent state hypothesis is not necessary and does not lead to a simpler explanation of the facts than can be had without it. Is it inconsistent with any of the facts? Considering first the reduction of sulphuric acid by copper, the following phenomena may be observed: When metallic copper, carefully cleaned, is heated gradually with concentrated sulphuric acid until sulphurous anhydride begins to be evolved, the surface of the copper becomes coated with a black crust. If the metal is now removed from the acid, then washed and placed in hydrochloric acid, the coating dissolves, forming a solution of copper chloride. In fact, this crust consists of copper oxide. Its formation is not explained by the hypothesis in question (eqs. 5–6) but is a direct confirmation of eq. 10. If the acid is reduced by hydrogen some of the hydrogen might be expected to escape unoxidized. In order to test this point pure sulphuric acid was heated with copper which was obtained by electrolysis from a recrystalized specimen of copper sulphate and subsequently ignited in an atmosphere of carbon monoxide. The gases evolved were collected over mercury and about 50 c. c. were treated with caustic potash. All was absorbed except a small bubble, which consisted essentially of oxygen. No hydrogen could be detected.

In order to demonstrate, however, that none had been formed it was necessary to show that if formed it would not be wholly oxidized by the hot acid. To get direct evidence upon this point, a quantity of nearly pure zinc was heated with the same acid that had served for the copper experiment and in the same way. Fifty c. c. of the evolved gas was only partly

absorbed by potash, a residue of about 3 c. c. being left. This residue consisted essentially of hydrogen.

The chain of evidence now appeared complete, for unless there were two kinds of nascent hydrogen it would be all oxidized in both cases *if in either*. the conditions being the same, and the fact that none was found in the copper experiment must be taken for valid proof that none was formed.

In reality the correct view would appear to be that at the temperature of the reaction the acid is for the greater part dissociated into H_2O and SO_3, the copper being oxidized by the latter only. The zinc acts upon the SO_3 forming SO_2, and also upon the undissociated part of the acid, setting free hydrogen which escapes.

Further light may be thrown upon this matter by a consideration of the reduction of the sulphuric acid by carbon. This reaction takes place at about the same temperature as that with copper, in accordance with the equation

$$C+2H_2\,SO_4=2H_2O+CO_2+2SO_2 \qquad [11$$

Here there can be no question of nascent hydrogen unless by assuming the existence of a sulphate of carbon, thus

$$C+2H_2SO_4=C(SO_4)_2+4H \qquad [12$$

which is wholly unwarranted, and there is no ground for supposing the mechanism of the action of carbon on sulphuric acid to be entirely different from that of copper on the same compound.

A favorite field in which nascent hydrogen often disports itself lies in the extremely complex reactions between nitric acid on the one hand and various metals on the other. Here the nitric acid may be reduced to ammonia, hydroxylamine, free nitrogen, nitrous acid, any of the oxides of nitrogen, and possibly still other products. Often many of them are simultaneously formed. Of these, ammonia and laughing gas and N_2 are never formed by the action of mercury, Bi., Cu. and Ag.[1] Iron, on the other hand, may reduce the whole of the nitric acid to ammonia. Montemartini, who has made a special study of this group of reactions[2], and others have shown that the various metals reduce nitric acid in various ways, giving reaction products in different proportions and of different kinds. The bearing of this upon the subject of the present paper is evident. If, for example, iron, zinc and copper all reduce nitric acid indirectly through the primary formation of nascent hydrogen, we would expect the ultimate products to be the same in kind and in relative amount, the absolute amount depending simply upon the quantity of hydrogen formed. Since this is not so, the conclusion is inevitable that the nascent hydrogen is not the reducing agent but the action of each metal is immediate and specific, removing oxygen from the acid and forming unstable intermediate products which elude direct observation but which, by their reactions, give rise to the products characteristic of each case.

I have endeavored, in this discussion, to select the fairest instances of the application of the nascent condition hypothesis and find myself forced to the conclusion that it is the survival of an obsolete doctrine; that it explains nothing which cannot be as well or better explained without it; that it cannot be reconciled in certain cases with known facts, and that,

[1] *Ber.* 92, 616, 898 f.
[2] *Loc. cit.*

therefore, we are not at present justified in the assumption that elements at the moment of formation or liberation from their compounds possess properties in any way different from those they commonly exhibit.

SOME PECULIARITIES OF SOLUTIONS OF FERRIC SULPHOCYANATE

BY LAUNCELOT ANDREWS, PH. D.

The deep blood-red color of solutions of ferric sulphocyanate has frequently been taken advantage of for the determination of small quantities of iron in river or spring water, in blood, in alloys, in alumcake, etc.

The earliest method of this kind, so far as I have been able to ascertain, is due to T. L. Herapath, who proposed to determine minute quantities of iron by the addition of potassium sulphocyanate to the acidified solution containing an unknown amount of iron, and also to a standard iron solution of known strength, the latter being then diluted until both showed the same tint.

Very similar methods have been employed or devised by A. Thomsen (*Ch. Soc. Jour.*, 47, 493), Ad. Joles (*Arch. f. Hygiene, XIII*, 402), L. Lapique (*Bull Soc. Chim.*, 2, 295, and by R. R. Tatlock (*Jour. Soc. Ch. Ind.* 6, 276).

Vierordt (*Quant.*, *Spektralanalyse*), suggested a fundamental modification of Herapath's colorimetric method, in that he dispensed wholly with a standard comparison solution, substituting for it a direct spectrophotometric determination of the amount of light of given wave length, transmitted by a layer of the ferric sulphocyanate solution one c. m. thick. In this method the assumption, based upon analogy, is made that the light absorbing power of the solution is directly proportional to the amount of iron contained therein; or in other words, *that the negative logarithm of the fraction of light transmitted is proportional to the concentration of the solution*, and the assumption seems to be confirmed by Vierordt's observations.

Subsequent investigations by Krüss and Moraht (*Lieb. Ann.*, 260, 193; *Kalorimetrie, u. Spektral analyse*, 1891, *p.* 125), and by Magnanini (*Zeit· phys. Ch.* 8,1) have shown the assumed proportionality to be non-existent in fact. If aqueous solution of ferric sulphocyanate be diluted its color fades away in a much more rapid ratio than corresponds to the diminishing concentration of the solution. The depth of color is much enhanced by an excess of either generatrix, *i. e.*, of KSCN or of $Fe\,Cl_3$, and as Magnanini has shown the change follows the laws of mass action qualitatively and quantitatively.

Magnanini dismisses the affair at this point as a *res adjudicata* assuming that the sulphocyanate is subject, in its solution in water, to a progressive electrolytic dissociation in the ions, Fe and S C N. In accordance with well

known principles this dissociation must become more complete with increasing dilution, and of course the formation of colorless ions from the colored salt must result in a diminution of the intensity of the color.

There is, however, another explanation not only possible, but probable. Ostwald has shown that other salts of ferric iron undergo in dilute solution more or less complete hydrolysis into colloidal ferric hydrate and free acid. If this hydrolysis also occurs in solutions, as we have no reason to doubt, of the sulphocyanate, in accordance with the equation.

$$Fe\,(SCN)_3 + 3\,H_2\,O = Fe\,(O\,H)_3 + 3\,H\,S\,C\,N,$$

It would offer a complete explanation of the phenomena hitherto observed.

II. EXPERIMENTAL PART.

In order to obtain further insight into the nature of the changes occurring upon dilution of solutions of ferric sulphocyanate, and indirectly of solutions in general, it seemed advisable to operate in solutions containing no water.

In such solutions the hydrolysis called for by the second theory given above could not occur and the electrolytic dissociation called for by the first theory could occur only in a subordinate degree. Hence both theories would lead us to expect that a solution of stated concentration of $Fe\,(SCN)_3$ in ether or in amyl alcohol or in absolute ethyl alcohol would have a much more intense color than a solution of the same strength in water, and second that the color would be proportional to the strength.

My observations have confirmed the first prediction, but not the second.

A solution in ether was first prepared containing 4.7 m. g. $Fe\,(S\,C\,N)_3$ per cu. cm., both the iron and sulphocyanogen being directly determined and found in accordance. From this solution, which was kept in the dark, the other solutions were prepared and their absorbtion coefficients determined by repeated observations in a Vierordt spectroscope with double symmetrical slit.

First.—Comparison of absorbtive power in amyl alcohol and water solutions. A solution containing .0625 m. g. $Fe\,(S\,C\,N)_3$ per c. c. of amyl alcohol transmitted 42 per cent of light of wave length 587, or about the same amount as an aqueous solution containing .247 m. g. per c. c., or nearly four times as strong.

I. Amyl alcohol containing .05 m. g. $Fe\,(S\,C\,N)_3$ per c. c., $T=15°$.

MIDDLE OF REGION.	PER CENT TRANSMITTED LIGHT.	EXTINCTION COEF.	ABSORBTION RATIO K.
617	84.0	.076	
589	56.2	.250	.200
564	42.5	.372	.134
517	19.1	.719	
501	16.0	.796	

II. Amyl alcohol containing .1 m. g. Fe $(SCN)_3$ per c. c. T—15°.

MIDDLE OF REGION.	PER CENT TRANSMITTED LIGHT.	EXTINCTION COEF.	ABSORBTION RATIO K.
617	41.0	.377	
589	14.8	.830	.120
564	6.8	1.167	

III. Amyl alcohol containing .094 m. g. Fe $(SCN)_3$ per c. c. T=18°. Older solution, stood 48 hours.

MIDDLE OF REGION.	PER CENT TRANSMITTED LIGHT.	EXTINCTION COEF.	ABSORBTION RATIO K.
622	61.0	.215	.436
599	42.9	.367	.263
568	12.2	.914	.104
556	9.0	1.045	.090

IV. Ethyl alcohol .094 m. g. Fe $(SCN)_3$ per c. c. T=18°.

MIDDLE OF REGION.	PER CENT TRANSMITTED LIGHT.	EXTINCTION COEF.	ABSORBTION RATIO K.
568	21.6	.665	
556	12.7	.896	

Other series of experiments with ethyl alcohol, amyl alcohol and ether, demonstrated that the absorbent power of solutions of ferric sulphocyanate in these menstrua diminishes more rapidly than the concentration. The amyl alcohol was distilled from phosphoric acid to remove traces of organic bases and then thoroughly dried. Hydrolysis of the ferric salt can therefor not occur.

If electrolytic dissociation occurs, the molecular conductivity of these solutions must increase with diminishing concentration and in proportion to the diminishing light-absorbing power.

The electrical resistance of the same solutions which had been examined optically was therefore determined in a resistance cell of the form described by Arrhenius, by Ostwald's method with Kohlrausch-Wheatstone bridge and telephone. The specific resistance of the amyl alcohol employed was about 100,000,000 ohms per m. m. cube.

All the measurements showed that the molecular conductivity of the non-aqueous solutions examined diminished with increasing dilution and in about the same ratio as the reciprocal of the absorbtion coefficient, whereas the molecular conductivity should be greater at high dilutions than at low if the tapering off of the color of the former is due to electrolytic dissociation.

I am not prepared to present final quantitative results at present because my apparatus is not perfectly adapted to the measurements of such high resistances, but there is no reason to question the qualitative results nor the general character of the numerical data. A cell now in course of construction having a much smaller resistance constant than that heretofore in use is expected to furnish results of the desired accuracy.

Ivan Klobukoff (Zeit. Phys. Chem. IV, 429,) has observed that solutions of hydrochloric acid in ether and in amyl alcohol exhibit a diminution of molecular conductivity with increasing dilution of the solutions and has shown that it is not due to any chemical action of the acid upon the alcohol. This phenomenon evidently belongs in the same class with that which I have observed in the case of ferric sulphocyanate solutions.

Neither of the theories as yet advanced seems capable of explaining all the facts and more extended studies of the spectroscopic and electrical behavior of other colored salts in non-aqueous solvents must be made before any theory can be advanced with profit.

ELECTROLYSIS OF SILVER—LABORATORY NOTES.

W. S. HENDRIXSON.

(Abstract.)

The author exhibited some pieces of apparatus devised in connection with his work on the atomic weight of tin, and also a quantity of pure silver prepared by electrolysis of the pure silver of Stas in strong nitric acid solution. The method of electrolysis was essentially that of Abrahall* as modified by Richards†. By using a strong acid solution containing fifteen per cent of silver and a battery consisting of sixteen gravity cells the silver was obtained in large crystals and no peroxide was formed at the positive pole. Separate experiments showed that silver deposited under these conditions, from a solution to which copper had been added, contained no trace of the latter metal.

The apparatus exhibited included:

1. A platinum condenser for the preparation in pure condition of such substances as attack glass or metals other than platinum, viz, water, hydrochloric, hydrobromic and nitric acids. Cork or other connections are avoided by selecting a retort into the neck of which the condenser tube fits closely. The first portion of the vapor condenses between the glass and platinum and forms a seal. The condenser tube is bent so that the neck of the retort or flask may be inclined upward to secure a back flow and to avoid the mechanical carrying over of substances by the spray.

2. A separatory funnel having a doubly-bored stop-cock like that in the well-known Lunge's nitrometer. On turning the cock to arrest the flow of the liquid the column in the stem, which in the ordinary funnel remains in the stem, being held by atmospherie pressure, falls at once since it is replaced by air which enters the stem through the second hole in the stop-cock.

* Journal Chem. Soc., 1892, p. 660.

† Proc. Amer. Academy, Vol. XXVIII, p. 22.

3. An adjustable attachment for a Bunsen burner, having three upright posts for the support of dishes, and a platinum triangle, made of wire, passing through holes near the tops of the posts, to support a crucible, watch-glass or small dish. The attachment permits the use of a "crown top" if it is desired to evaporate a liquid rapidly without boiling, and it is provided with supports for a cylindrical chimney which encircles the posts and protects the flame from drafts of air.

4. An apparatus for electrolysis, consisting of a dessicator containing a platinum triangle to support a platinum dish. A wire of the same metal is connected with the triangle and passes through the side of the dessicator. To prevent loss by spray, the dish is covered by a large watch-glass, in which is sealed a large platinum wire ending in a spiral below to serve as the positive electrode. The wire extends through a very small cork fitted in the top of the dessicator, and thus can be raised, lowered or supported in any position.

EXPERIMENTAL ENGINEERING AT THE IOWA AGRICULTURAL COLLEGE.

BY G. W. BISSELL, PROFESSOR OF MECHANICAL ENGINEERING.

Experimental engineering at the Iowa Agricultural College is of two kinds. The first kind has for its object the instruction of the student in the use of and calibration of the instruments employed, and in the performance by improved methods of a series of graded experiments whose variety and selection are such as experience has shown to be productive of the best results attainable with the facilities of the laboratory.

The experiments under this head which are conducted by the students in mechanical engineering are: Tension, transverse and compression tests of the materials of construction, properties of lubricants, measurements of power by absorption and transmission dynamometers, steam gauge and indicator spring calibration, cement testing, fan-blower tests, calorimetry, weir and water-meter calibration, efficiency tests of steam engines, boilers, injectors, air compressor and steam heating, electric lighting and pumping plants, and the thermal analysis of the steam engine.

Owing to the number of experiments and students and the lack of duplicate apparatus, it is necessary as well as advisable to maintain all apparatus in working order, so that the student is not obliged to lose time and patience and courage in looking for things. While the experience obtained in arranging apparatus might be useful as instruction, such preliminaries are apt to discourage the beginner. Moreover, the practice, if followed with large classes, would cause confusion and sacrifice discipline. System is necessary in this particular.

The actual performance of the above or any other set of experiments is secondary to another feature of the work, which consists in the writing of

a satisfactory report of the experiments. This report includes several distinct things, and is generally arranged under heads as follows:

1. Object of the experiment.
2. Method to be employed in attaining it. Under this head is placed the derivation of the fundamental formulae for the experiment.
3. Description of apparatus. This includes all apparatus, principal or accessory. The description is often assisted by sketches.
4. Describe the experiment. Every operation having direct or indirect bearing on the results.
5. Give numerical data. These are usually taken on printed blanks and afterward copied on similar blanks for pasting in the note books.
6. Derive results.
7. Draw conclusions.

When the student has the results obtained from the above experiments upon the pages of his note book he has a valuable store of knowledge to draw upon in his future work. For the tests of the materials of construction he finds certain constants. Experimenting with lubricants shows him that the value of an oil for lubrication depends upon many properties. Testing the transmission of power by various devices opens his eyes to the extent of the friction losses, resistance of the air, etc. The calibration of instruments, calorimetry, flue-gas analysis are essential in establishing the value of the efficiency tests; and from these efficiency tests, he learns, above all, the value of accuracy in each and every step and the importance of perfect honesty in the recording of observations.

With the exceptions of the tests upon materials, the numerical results of much of this work are far from correct because of the inexperience of the experimenters and because also of the variability of conditions peculiar to engineering problems. The exactness of the physical and chemical laboratories are unusual in the engineering laboratory. But education and not figures is the result sought by the instructors. Professor Carpenter, in charge of experimental engineering at Sibley College, Cornell University, says "The undergraduate laboratory should be equipped so as to demonstrate in a practical and convincing way the principal laws or facts that the student must master in order to finish his course. Its course of instruction should be such as to require systematic work of the student, teach him how to observe, how to use apparatus, how to deduce conclusions from his mass of data and finally how to make a neat and systematic report of his work."*

Having completed, or nearly so, the above outlined work, the student takes up the second kind of experimental work which is offered to him chiefly in the form of thesis work. That "there's nothing new under the sun" cannot be said of man's knowledge. And in engineering there are countless problems still unsolved for the lack of evidence which those actively engaged in professional work have not the time to gather and the technical schools are expected to help by contributing facts. Hence the necessity for original work in the technical schools. This can almost always be accomplished by assigning it to students as thesis work and the results of so doing when the instructor can give personal supervision to the work are good. Educationally, the results are good because the student is thrown largely upon his own resources and because in opening the gates to the new

*Engineering Laboratories, R. C. Carpenter. *Science*, November 3, 1893.

fields of knowledge thus brought to view he has new experiences and new thoughts and is taught the increased importance of application, reasoning and preliminary training. In short we aim to benefit first the student and next the profession by the second kind of experimental work.

The time spent on thesis investigation and writing ranges in amount from one hundred to two hundred hours of actual work.

The scope of the original work in experimental engineering for the past two years is indicated by the following subjects chosen from the whole number assigned:

The force exerted in cutting cast iron, wrought iron and steel in the lathe.—For cast iron the force is proportional to the amount of metal removed. For wrought iron and steel the force does not increase as rapidly as the amount ot metal removed.

Determination of the point pressure and twisting moment exerted by twist drills in cast iron, steel and brass.—A collection of data useful in the design of drill presses.

The resistance of swing check valves in the return pipes of steam heating systems.—Found to be very slight, indeed—not over one-quarter of a pound.

Some of those projected for the coming year are:

Friction of cylinder oils.

Variation of stress in the punching of metals.

Variation of economy of the steam engine with change of load.

Experiments with small venturi meters.

In the other departments of the engineering, electrical, civil and mining, the experimental work plays an important part and is prosecuted with vigor by the instructors and students.

Ames, Iowa, December 26, 1893.

ON THE GEOLOGICAL POSITION OF BENNETTITES DACOTENSIS MACBRIDE, WITH REMARKS ON THE STRATIGRAPHY OF THE REGION IN WHICH THE SPECIES WAS DISCOVERED.

BY SAMUEL CALVIN, IOWA CITY.

Since Professor Macbride's paper on *Bennettites dacotensis* was published in the *American Geologist* for October, 1893, there have been numerous inquiries respecting the exact geological horizon from which the cycads were derived. The close resemblance and the intimate relationship indicated between the Dakota fossil and *Tysonia marylandica* Fontaine, while not conclusive, would point toward a common horizon for the two species, and so make it possible to correlate the Potomac formation with a definite Mesozoic horizon in the northwest. Prosessor Macbride's paper left

the stratigraphical position of his species undecided. To settle, if possible, the question definitely, the writer recently made a visit to the locality that furnished the types of Macbride's species.

Specimens of Bennettites are not very numerous in the Black Hills of South Dakota. At all events not very many have yet been brought to light. All the individuals at present known have been found in a rather limited area around Minnekahta, a small station on the Deadwood branch of the B & M. railway. By far the greater number, some forty or fifty altogether, were discovered on an area of only a few acres, about four or five miles southwest of Minnekahta. They all lay partly imbedded in the soil on the southern slope of one of the low, rounded, grassy hills that characterize the marginal portion of the Black Hills uplift. Separating the cycad hill from the next on the south is a comparatively shallow, but steep sided cañon, supporting a moderately dense growth of *Pinus ponderosa* Douglass. The walls of the cañon reveal the edges of gently folded and tilted beds of sandstone. Sandstones—yellow, brown or red, sometimes in massive, and sometimes in thinner layers—often project above the grassy surface on the gentler slopes above the cañon walls; while here and there are high buttes rising two or three hundred feet above the general level, and composed of conformable beds of sandstone throughout their entire elevation. A single sandstone formation therefore, extends from the bottom of the small secondary canyons of the region to the top of the buttes; and, though no cycads were seen in place, there is no reason to doubt that it was in this sandstone, at some level, that they were originally imbedded. The sandstone exhibits the characteristics of the Dakota group of the Black Hills as described by Hayden, Winchell and Newton; still it was thought best not to decide the question of its age on lithological grounds alone. Diligent search during the time at our disposal failed to disclose the remains of recognizable plants or animals belonging to the sandstone in place. Fragments of silicified trunks, probably of deciduous trees, lay loose on the surface. Some of these were mingled with the cycad trunks, and, since the condition of mineralization was the same in both, it was inferred that the silicified trunks of both types had been imbedded under the same conditions, and that they probably came from the same horizon. A short distance east of the cycad field a gray shale, supposed to be the Jurassic of the geologists who have written on the Black Hills, was revealed by an upward arching fold in the bottom of the canyon, but as it contained no fossils judgment was for a time reserved. Three or four miles west of the main group of cycads the ash colored shales, recognized beyond a doubt by *Belemnites densus*, M. and H., and other characteristic fossils as the Black Hills "Jurassic" are exposed in full force in the east side of Big Horn basin. The whole thickness of the Jurassic, two hundred feet or more, is thus revealed; while beneath the Jurassic shales, at the bottom of the basin-like valley, there is an exposure of Red Beds having a thickness of twenty or thirty feet. The rim of Big Horn basin, on the east side at least, exhibits ten or twelve feet of heavy, cross bedded sandstone resting directly on the Jurassic shales. These cross bedded layers constitute the base of the great sandstone formation, to which reference has already been made. The formation extends from the Jurassic shales to the summits of the adjacent buttes. On stratigraphical evidence we are now prepared to recognize it as the Dakota

sandstone. The cycad beds are therefore Cretaceous and belong to Meek and Hayden's Cretaceous No. 1.

A considerable thickness of the sandstone at the top of all the higher buttes of the region has been converted into a very hard, brittle quartzite. The process of vitrification has in some instances almost completely obliterated the original structure; in other cases the original grains are seen imbedded in a a secondary deposit of silica. Contrary to the opinion of some observers, I believe the vitrification to be due to conditions that existed in the sea at the time the beds were deposited. The waters were charged with an unusal amount of soluble silica, which was not only precipitated among the sand grains, converting the whole mass into a homogeneous quartzite, but some of it was substituted for the molecules of wood and other tissues in the stems of cycads and deciduous trees, that by accident were floated in from adjacent lands. The silicified trunks of ordinary trees now found on the lower slopes occupied by the sandstone are very much broken and weathered and polished by long exposure. On the shoulder of one of the buttes a mile or two west of the main cycad field, not far below the level of the vitrified bed, there was noted a silicified log two feet in diameter at the base, twelve feet of the basal part unbroken, with a train of fragments of varying dimensions extending from the smaller end far enough to indicate an original length of seventy or eighty feet The fresh appearance of this specimen, with its fractures all sharp angled and its parts of considerable length all in their natural relative positions, was in striking contrast with the short, polished, worn, disassociated fragments found in the residual soil on surfaces two or three hundred feet lower. The differences in condition and appearance indicate enormous differences in the length of time the specimens have been exposed. The effects on the better preserved specimen, of rain and frost and wind driven sands, with frequent falls from undermining cliffs, during the years necessary to reduce the hill on which it lies to the level now occupied by the fragments with which it is compared, will not be left to conjecture so long as the worn and dismembered fragments lying at lower levels remain to furnish objective illustrations of what those effects have been in the past. These are reasons for the conclusion that all the silicified trunks, including those of Bennettites, came from the same horizon, and that that horizon was the vitrified beds near the summit of the Dakota sandstone.

East of the valley followed in this vicinity by the B. & M. railway, rises Arnold's peak, a high butte, the summit eight hundred feet above the valley, and like the other high points of the region, capped with vitrified sandstone. The geological structure at the base is concealed. but a mile or two farther north, almost directly east of Minnekahta, the high ridge of which Arnold's peak is simply the most prominent part, reveals at its base the belemnite-bearing beds of the Jurassic. The plain on which Minnekahta stands is some scores of feet below the top of the Jurassic, and not less than six hundred feet below the vitrified sandstone near the summit of the Dakota group. On this plain a few specimens of Bennettites have been found, but in most cases they were so far decomposed as to fall to pieces when attempts were made to remove them. Again we find some relation between the abrasion and decomposition that the fossils have undergone and the vertical distance they lie beneath the level of the vitrified beds. Assuming that all

the fossils were imbedded at essentially the same horizon, then those that now occupy the lowest level haye been longest exposed to atmospheric and aqueous agencies.

At Hot Springs, about twenty miles as one has to travel from the principal group of cycads, the valley of Fall river has been cut down through the entire thickness of the Dakota sandstone, through all the Jurassic, and down into the purple limestone and gypsiferous red clays of the Red Beds. Battle Mountain, east of the town of Hot Springs, has an elevation of about a thousand feet above the valley. The upper part of the mountain is composed of the Dakota sandstone, and away up at the summit is the quartzite seen on the higher eminences around Minnekahta. Fall river, formerly known as Minnekahta creek, flows off toward the southeast to join the south fork of the Cheyenne river. About four miles from Hot Springs, the stream emerges from the sandstone hills in a series of cascades which constitute the falls of Fall river. At the falls, as previously observed by Newton, the sandstone is inclined at a high angle and passes beneath the dark colored shales of the Fort Benton group. Crossing the nearly level plain that separates the last of the sandstone hills from a high escarpment that curves around nearly parallel to the margin of the uplift, we find ourselves on calcareous beds of the Niobrara group. These are charged with *Inoceramus problematicus* Schlotheim, with occasional colonies of *Ostrea congesta*, the whole aspect of the formation resembling closely the Inoceramus bearing beds near Sioux City, Iowa, and Ponca, Nebraska. The similarity of the Sioux City deposits to Niobrara beds on French creek, a locality probably thirty miles northeast of the point just noted, was remarked by Prof. N. H. Winchell in 1874.

Over on the Cheyenne river, about six miles east of Fall River Falls, is an exposure of Niobrara that reminds one of the massive chalk beds at St. Helena, Nebraska. The resemblance is not complete, for at St. Helena the beds are for the most part white, only occasionally portions are bluish in color owing to the presence of organic matter. On the Cheyenne the beds are all bluish. They give out a strong fœtid odor when struck with the hammer. There are indications of the presence of organic matter in unusual amount. But the massive bedding of the soft, calcareous material, the manner in which the layers break down, the huge blocks of talus, the occasional small colonies of *Ostrea congesta*, the vertebræ and scales of fishes, are each and all perfectly duplicated at the two points mentioned; namely, on the Missouri at St. Helena, and on the south fork of the Cheyenne southeast of Hot Springs.

Around Edgemont, south of the hills, the country for some distance is occupied by the Fort Benton shales. A steep escarpment which constitutes the vertical face of the first terrace south of Cheyenne, reveals with their usual characteristics, the Inoceramus beds of the Niobrara; but passing on southwest over the hills toward the valley of Cottonwood creek, the Fort Benton is again exposed. Erosion of the shales has formed a series of Bad Lands on a diminutive scale. It has at the same time made prominent certain beds of impure limestone, from which we obtained numerous fossils. Among the collections here were specimens of *Prionocyclus wyomingensis* Meek, *Scaphites warreni*, Meek, *Lunatia concinna* M. and H., *Inoceramus pseudo-mytiloides* Scheil, two or three other species of Inoceramus, a Pteria or two, and many other less obtrusive forms that have not yet been identified.

At the town of Hot Springs some portions of the valley are occupied by horizontal beds of a very coarse conglomerate that lies unconformably on the folded and tilted Red Beds. The thickness of the conglomerate is about forty feet. It is composed of fragments of all the harder formations from the crystalline rocks at the center of the uplift to the purple limestone of the Red Beds and the quartzite of the Cretaceous. When the conglomerate was deposited the valley had essentially its present depth. In some places the streams have just fairly completed the work of cutting through the conglomerate, in other places they have cut twenty or thirty feet below its base. This conglomerate is probably the equivalent of that lying at the base of the White river Miocene. If so it would indicate an enormous amount of erosion between the beginning and middle of the Tertiary as compared with the amount accomplished since.

Returning finally to the main object for which these observations were undertaken, it is clear that *Bennettites dacotensis* Macbride, belongs to the Cretaceous period, and the evidence is practically conclusive that the exact horizon at which the individuals of the species were imbedded is represented by the uppermost layers of the Dakota sandstone.

NOTES ON THE LOWER STRATA OF THE DEVONIAN SERIES IN IOWA.

BY WILLIAM HARMON NORTON.

In a report recently made to the State Geological Survey, the writer communicates in detail some facts regarding the brecciated zone of the Devonian in Linn county, Iowa, and the terranes subjacent. The following is in part a brief summary of this report:

In the breccia which occupies the same horizon from Davenport to Fayette, and which has been termed by McGee the Fayette breccia, four stages are discriminated.

The fourth, or upper stage, involves in Linn county to a greater or less extent several life-zones of the Cedar Valley limestone, including the horizons of *Acervularia davidsoni* (E. and H.), *Phillipsastrea gigas* (Owen), *Spirifera pennata* (Owen), and *Spirifera dimesialis* (Hall). Matrix and fragments are alike being fossiliferous and shaly, and the fragments are usually large and often but slightly disturbed.

The third stage is distinguished by the predominance of fragmental masses, often large and rectangular, of a tough, grey, crystalline or semi-crystalline, heavily bedded limestone, containing a distinct fauna, of which a large *Gyroceras* and *Rhynchonella intermedia* (Barris) are the most characteristic fossils, and *Gypidula occidentalis* (Hall) and *Orthis macfarlandi* (Meek), the most common. The limestone of which these fragments is composed is not found in place in Linn county.

The second stage is defined by the abundance of fragments, usually small, of a hard, drab, unfossiliferous limestone of finest grain, often thinly bedded, often finely laminated, the laminæ frequently being flexed or contorted. This limestone also is not found undisturbed in Linn county.

The first stage is characterized by an abundant buff or brown matrix, the fragments being sparse and small. Some of them are quartzose, belonging like the matrix to the subjacent terrane.

This subjacent terrane, locally called the Kenwood beds, consists of massive argillaceous and ferruginous buff and reddish-brown limestones, irregularly bedded, often flexed and arched and passing horizontally and vertically beneath into buff thinly laminated or shaly limestone, weathering into slopes of marly clay. In these beds nodules of crystalline quartz with calcite and angular fragments of the same are common. Beneath the buff shales which constitute the bulk of the Kenwood beds lies a layer of greenish or bluish fissile shale from a few inches to five feet thick. The upper limestones are usually involved, more or less in the Fayette breccia. The total thickness of the Kenwood beds is nearly forty feet. The basal blue shale in especial is believed to represent the horizon of the Independence shales. The latter term, originally designating some sixteen feet of dark carbonaceous and grey fossiliferous shale pierced by a well near Independence, may readily be extended, however, to include all the limestone and shale of the Kenwood. The latter term is, therefore, used only as a local synonym for the Independence shales, of which it offers many natural sections, the first discovered.

Beneath the Kenwood beds in Linn county lies a Devonian terrane not hitherto known, termed the Otis beds. Like the Kenwood beds, from which it is somewhat sharply divided, the Otis limestone is remarkably constant and uniform in its lithological features, some layers with special characteristics being traced across the county. It consists of nearly pure non-magnesian limestones, some macro-crystalline and some non-crystalline and compacted of impalpable calcareous silt, often heterogeneous in texture, often lying in heavy lenticular masses, passing into thin calcareous plates. In all the numerous exposures of these beds from the Cedar River above and below Cedar Rapids to near the Jones county line southeast of Springville, *Spirifera subumbona* (Hall) is found gregarious in a typical form distinct from the varietal form found in the Independence shales at Independence. On the Buffalo and Wapsipinnicon rivers the numerous sections of the Otis limestone are unfossiliferous. The Otis beds, whose total thickness is thirty feet, include hard thinly-bedded magnesian limestone basal layers by which they pass without unconformity into softer heavily bedded dolomitic limestones, probably Silurian in age, provisionally called the Coggan beds.

It is believed that the Devonian succession in Linn county will be found to obtain elsewhere in the State where the lower strata of the system are exposed.

At Davenport, for example, the lower limestone out-cropping along the Mississippi river from the city northward to Gilbertsville, thinly bedded, arched and partially brecciated, is identical in appearance with the fragments of the second stage of the Fayette breccia from Fayette to Cedar Rapids. Under the saddles of its folds there emerges a brown ferruginous limestone indistinguishable from the Upper Kenwood, whose horizon it

seems to occupy. Lithologically and paleontologically the fossiliferous beds resting on these limestones at Davenport, referred by Barris to the Corniferous, are believed to be equivalent to the *Gypidula occidentalis* and *Rhynchonella intermedia* limestone, whose presence defines the third stage of the breccia in Linn county, and which in Buchanan county has been named the Gyroceras beds. At Davenport, as in the counties to the northwest, the Gyroceras beds are succeeded by a soft, shaly limestone with a characteristic fauna.

The writer has felt the need of definite terms to designate these beds, and therefore suggests for the consideration of workers in this field the name, *Lower Davenport beds* for the lower unfossiliferous limestone at Davenport, the limestone which furnished the fragments for the second stage of the Fayette breccia. If a geographical as well a paleontological term should be found convenient for the fossiliferous limestone overlying these lower beds, the term Upper Davenport beds could be appropriately used as a synonym of the Gyroceras beds.

The change in fauna is so distinct at the summit of the Gyroceras beds that it seems to the writer that they should be separated from the Cedar Valley limestones, as the Independence shales have been.

If the inferences we have drawn are correct, the "Upper Helderberg" of Hall, and the "Corniferous" of Barris, at Davenport, are superior to the horizon of the Independence shales. They must therefore be included in that broad biotic unity whose termini are the Independence shales and the Lime creek shales, whose fauna have been shown by Calvin to be so similar.

It is an interesting fact that the new Devonian terrane, the Otis beds, found beneath the Independence shales, contains, as we have stated, as its characteristic fossil a Hamilton and Chemung species, and carries no species, so far as known, allied to pre-Hamilton faunas in other states.

Geological Laboratory of Cornell College, December 28, 1893.

CRETACEOUS FORMATIONS OF NORTHWESTERN IOWA.

BY CHARLES R. KEYES.

(*Abstract.*)

Until recently little definite information has been accessible concerning the distribution and subdivisions of the Cretaceous deposits of Northwestern Iowa. Strata of Cretaceous age have been recognized from time to time at various points, but, as a rule, little detailed information has been recorded. As early as 1840 Nicollet called attention to certain sections near the mouth of the Sioux river which he regarded as Cretaceous in age. Since that time Cappellini, Marcou, Meek, Hayden, White and others have been through this region. In all these cases the rocks noted were in the immediate vicinity of the Missouri river. White gave more attention, perhaps, to

the Iowa strata than any of the other writers mentioned, and recognized outliers as far east as Guthrie county and as far south as Montgomery county.

Recently numerous deep well records and field observations have shown that the Cretaceous deposits cover a much larger area than has hitherto been recorded. The northwestern fourth or fifth of the State may now be regarded as occupied by deposits of Cretaceous age. White, in considering the Iowa Cretaceous, divided the beds as found in the Sioux river region into the Woodbury shales and sandstones and the Inoceramus beds. As recently shown by Calvin the Woodbury shales are equivalent to the Dakota sandstone and the Fort Benton shales of Meek and Hayden and the Inoceramus beds are the same as the Niobrara of the same authors. Thus three of the formations differentiated by Meek and Hayden are known to be well represented in Iowa. During the past season another formation of the Cretaceous age has been found to extend into Iowa. This is the Fort Pierre shale. It was first noticed in the State by Mr. H. F. Bain, who found it well developed in the vicinity of Hawarden, in Sioux county, where it attains a considerable thickness. The easternmost location heretofore known showing the Fort Pierre beds has been Yankton, South Dakota, at which place the deposits are used largely in the manufacture of Portland cement.

There is another division of the Cretaceous of the upper Missouri valley which Meek and Hayden have recognized, This is the Fox Hills group. It will be seen, therefore, that four out of the five Cretaceous formations of the region are now known to extend into the State of Iowa.

Incidentally it may be mentioned that the Niobrara chalks have been recently recognized as far east as Auburn in the southeastern part of Sac county, eighty miles east of any hiterto reported locality. The Cretaceous deposits have also been extended southward by Mr. E. H. Lonsdale nearly to the Missouri line. The gypsum deposits of Webster county, Iowa, are also thought to belong to this age. It may not be out of place here to mention the fact that in the drift of northwestern Iowa boulders have been found consisting of soft friable ferruginous sandstone, highly fossiliferous, the organic remains being characteristic Fox Hills forms. As remarked by White the presence of the friable sandstone blocks indicates that they are not far removed from their original localities. It would not, therefore, be wholly unexpected should outliers of the Fox Hills group yet be found within the limits of Iowa.

DERIVATION OF THE UNIONE FAUNA OF THE NORTHWEST.

BY CHARLES R. KEYES.

One of the most striking features in the zoological history of the Mississippi basin is the exceedingly rich and varied moluscan fauna, which is characterized particularly by the Unio family, including all the common river mussels. The great abundance of individuals, the large number of

forms and the wide geographic range of many of the varieties has perhaps no parallel elsewhere. The first of these statements requires no further proof to one who has worked anywhere within the limits of the region under consideration. The second proposition finds ample evidence in collections of more than sixty different kinds of these mollusks from a single locality. Altogether more than seven hundred species of the family Unionidæ have been described from North America—over four-fifths of the entire number known to exist in the world. Having such a large number of closely related forms to deal with, it has become very convenient, and indeed very necessary, to separate the chief genus into a number of subordinate groups, naming each after its leading species; thus the sections are known as the "gibbosus," "undulatus" groups, etc.

The distribution in space of the uniones of the continental interior has been shown to be in many respects very peculiar. As the problem finds no satisfactory solution in an ordinary zoological treatment, an inquiry has naturally been made in regard to how far the present regional disposition of the various groups may have been determined by the conditions of former geological epochs. This involves by far the most important factor in the consideration of the present geographic distribution of organisms, and one which continually assumes greater and greater prominence in dealing with facts pertaining to that subject.

It has also been clearly shown in other zoological families that the range of many genera and species in time is very much more extended than has been generally regarded, and that some of the living types have a high antiquity. The recent discoveries of rich land and freshwater faunæ in the Mesozoic and later deposits of the Northwest have done much toward elucidating the early history of American fluviatile mollusks. White* has already intimated in a general way the probable close genetic relationship of these fossil uniones and the forms now living in the waters tributary to the Mississippi river, but no specific references were made to the mollusks now existing. Later† it was incidentally mentioned that among the Laramie Unionidæ were found the prototypes of *Unio ligamentinus*, *U. undulatus* and other groups.

In the upper Mississippi region the Unionidæ are easily separable into three grand sections which are commonly ranked as genera: Anodonta, Margaritana and Unio. The generic distinctions are based entirely upon the characters of the hinge "teeth;" but there are also other good structural features to support this separation; and the transitions are few and not well marked. The leading North American groups of Unio may be typified by the following species: *Unio ligamentinus* Lam., *U. undulatus* Barnes, *U. ellipsis* Lea, *U. gibbosus* Barnes, *U. tuberculatus* Barnes, *U. pustulosus* Lea and *U. parvus* Lea, besides others which have no bearing in the present connection. Of these at least five groups are known to have fossil representations in some portion of the western Cretaceous or Tertiary strata. In the present consideration no forms from rocks earlier than the Mesozoic age are considered, for the reason that so much doubt at present exists concerning the shells referred to the Unionidæ from the Devonian and Carboniferous of this country. As regards the Tertiary forms described under Anodonta and

*U. S. Geol. Sur., 3rd Ann. Rep., 1883.

†Keyes: Annot. Cat. Iowa Mol., Bul. Essex Inst., vol. xx, 1889.

Margaritana considerable confusion also prevails; and it is quite certain that some of the species have been wrongly referred to these genera.

It has been stated by Binney and others that among the living land mollusks a wide geographic distribution is indicative of a high antiquity for the group. This observation has lately* been extended to certain Carboniferous mollusks. By carefully reviewing the American Unionidæ it will be found that the generalization is applicable to this family also. Those (subgeneric) groups having the widest geographical range at the present time in the basin of the Mississippi river are the ones which are best represented in the Mesozoic strata of the upper Missouri region. As examples, *Unio ligamentinus*, *U. ellipsis*, *U. undulatus* and *U. rectus* are the most prominent, perhaps. These four species range from Ottawa, Canada, and western New York, to southwestern Kansas and Texas, and from Alabama to northern Minnesota and Dakota. All four groups, along with others, are present in considerable numbers in the freshwater Laramie deposits of the Northwest.

Of the group typified by the first species mentioned—*Unio ligamentinus*—there are a number of forms now known among the fossil Uniones. The shell of the living representative is exceedingly variable, as might naturally be expected of a species occurring under the many diverse conditions of environment such as are imposed by its wide geographical distribution. Throughout its range many specific terms have been applied to the various varietal forms. In some localities this species has a very thin and fragile shell; in others the shell is very thick and massive, with large, heavy hinge-teeth, and rough, deep, muscular impressions, resembling in many respects the early described *Unio crassidens* of Lamarck. To the latter category the majority of the Laramie forms of the group appear most closely to approach, particularly such shells as *Unio vetustus* Meek, from southwestern Wyoming. *U. priscus* M. and H., seems also to belong to the group. The type continued through the Eocene as *U. shoshonensis* White.

Unio ellipsis is the type of a rather large and variable group of shells. The beaks in this species are far forward, even extending beyond the anterior margin of the shell. It is thus a representative of a series having but few examples among the forms at present living, but which was almost universal among the Laramie species, as was first pointed out by White. The most nearly related of the fossil species now known is perhaps *U. proavitus* W., but in the former the "teeth" are somewhat heavier and the outline more rotund. Other forms of this type are are found in *U. cryptorhynchus* and *U. propheticus*.

Unio gonionotis White, is evidently one of the "undulatus" group; but it more closely resembles some other members of this section rather than the leading species itself. *U. belliplicatus*, while differing considerably from the type of the group, is believed to have a close relationship with other members of the section, particularly certain forms that have recently been noted from Kansas.

The *Unio rectus* group is characterized by rather large, elongate forms, having heavy shells, rounded in front, and more or less attenuated behind. The Laramie representatives are best known under *U. couesi* W., and perhaps also *U. danæ* M. and H. In the Eocene *U. clinopisthus* appears to have flourished as the descendant of the early "gibbosus," or "rectus" type.

*Proc. Acad. Nat. Sci., Phila., 1888, p. 245.

Among the fossils already alluded to are a number of Anodontæ, the most prominent of which is *A. prepatoris*, a member of the "grandis" group. Margaritana has been reported from the Cretaceous, but at present there is much doubt as to the correct reference of the form to this genus.

At present the oldest American form of Unio is *U. cristonensis* Meek. It was described from a horizon doubtfully referable to the Triassic, and was first figured by White. The type specimens are imperfect, but show distinctly the generic characters.

White* has expressly called attention to the fact of the extreme shortening of the Laramie Uniones in front of the beaks, or rather the forward position of the umbones as compared with the modern shells. This fact is of great interest in its bearing upon the phylogeny of the group, as it is an important consideration in support of Neumayr's recently advanced suggestion concerning the derivation of the Uniones from the Trigonidæ. Should this near relationship of the two families be established it is very probable that the view just mentioned would require some slight modification. For the two families had already, in the Cretaceous, become very much differentiated, so that the two types were probably derived from a common, but rather remote ancestor, rather than one from the other.

A most remarkable feature concerning the Unione fauna of North America is the striking individuality of the forms of each drainage basin, however limited it may be. This peculiarity is so marked that one acquainted with the American species of the family has little difficulty in telling from which particular portion of the country, or indeed the stream, a given series of shells was taken, even when the most widely distributed species are under consideration. It was probably this fact more than any other that occasioned the vast multiplication of species by Lea whose wide familiarity with these bivalves enabled him from the external characters alone to readily determine the locality of the various forms of Unionidæ brought to his notice. It is, perhaps, one of the best known examples showing how persistent, how exclusive, how united a particular fauna of a limited geographic area may be, when the physical conditions are seemingly quite diverse. It also illustrates how well the peculiarities of two contiguous basins may be fully preserved even when the conditions of environment are presumably the same. A hint towards a partial explanation of these phenomena is derived from geological data concerning the permanency of river basins; for it has been satisfactorily shown that the water courses are among the longest lived of all the topographical features of a region. This being the case the Unionidæ would be admirably adapted to flourish through long periods of time and undergo but slight structural modifications, and this certainly seems true of these bivalves in the Missouri basin, for they have come down from Mesozoic times almost unchanged.

The distinctness of unione faunæ in separate drainage basins has some striking illustrations in the upper Mississippi valley. One in particular has recently been brought into notice in the case of the Des Moines and Iowa rivers, which flow parallel to one another southeastward across the State of Iowa. The peculiar distribution of the lamellibranchs in the eastern and western portions of the State was pointed out some time ago in an annotated catalogue of the Mollusca of Iowa. Of the species found in

*U. S. Geol. Sur., 3rd Ann. Rep., p. 431, 1884.

the Des Moines river there are seven that do not occur in the Iowa, while in the latter stream there are twenty-one forms that are not found in the former; twenty-six species are common to both rivers. Of the latter, four are rare in the Iowa but abundant in the Des Moines, while two are rare in the last mentioned water course and common in the eastern stream.

Now the molluscan fauna of the Iowa is identical with that of the Minnesota river, suggesting that an intimate connection may have existed, at a period not very remote, between the latter stream with some one of the drainage basins of eastern Iowa. That the connection was probably of a comparatively recent date is shown by the distribution of the living Unionidæ in the upper Mississippi valley which points strongly to the wide-spread influence of certain peculiar agencies during glacial times which modified the former range of the mollusks of the region. The present topography, however, of southern Minnesota, does not seem to exhibit any direct indications of such a relation as is above alluded to, except in the central part. But it is probable, as has been urged by Chamberlain, McGee and others, that during the glacial period the elevation above the sea level of the region under consideration was very different from that of the present time. The objection raised by the previous statement therefore loses most of its force.

The persistence, with such slight structural modifications, of the members of the Unionidæ for the long period of time that must have elapsed since the close of the Cretaceous appears to indicate a high antiquity for this type of molluscan life. But since so very little or nothing is known concerning the internal characters of the shells of the Paleozoic lamellibranchs, it is very probable that a number of other Unio representatives will be found among forms already described under genera not at all related. On the other hand future research will doubtless bring to light new types connecting more closely the family with others. In this connection it is of interest to note that Whiteaves has lately described some lamellibranchs from the Coal Measures of Nova Scotia which with little doubt possess characters which would cause great difficulty in the attempt to separate the forms from typical Unio.

PROCESS OF FORMATION OF CERTAIN QUARTZITES.

BY CHARLES R. KEYES.

(*Abstract.*)

In the extreme northwestern corner of Iowa there is a small area of very hard, thoroughly vitreous rock, which has been known for more than a quarter of a century as the Sioux quartzite. The mass is also well exposed in the adjoining portions of Minnesota and South Dakota. The Sioux "granite," as it is now locally called among quarrymen, is of considerable

interest for the reason that it has long been the only altered formation known within the limits of Iowa. The apparent metamorphic characters of the quartzite beds is all the more remarkable from the fact that the rocks of the State are so horizontal in their position, so undisturbed by mountain making forces, and so unchanged in lithological characters that it is commonly supposed that all the strata of the State are essentially the same as when deposited in the quiet waters of the great interior sea which once occupied the heart of the American continent.

Although so thoroughly crystalline and so closely resembling quartzitic rocks altered from sand beds through regional or contact metamorphism no massive crystallines have been mentioned in connection with the Sioux quartzite until quite lately when a large mass of diabase was discovered in the midst of the quartzite of southeastern Dakota. Still more recent borings in northwestern Iowa have revealed no great distance below the surface other rocks of undoubted eruptive origin among which may be mentioned quartz-porphyry.

The Sioux quartzite formation has received considerable attention from time to time, but for the most part the observations have been somewhat cursory; incidental to other examinations rather than special examinations.

Irving's description of the lithological features of this formation essentially agrees with observations made during the past few months. It is as follows:

"Loose sandstone to the hardest and most complete vitreous quartzite, the prevalent phase being a distinctly quartzitic one. The loosest and most completely indurated portions are arranged in the most irregular relations to one another. Occasionally they will be interstratified. At times the exposed parts will be completely vitrified, while below artificial openings will display an entirely loose sandstone, suggesting an induration of the exposed portions by weathering. In other cases, however, exactly the reverse of this will be met with, while very often the more and less indurated phases pass into each other laterally by rapid graduations, the two phases traversing the layers and dovetailing into each other in the most irregular manner. The prevalent color of the formation is red, but the loosest varieties are often very pale colored, while the most vitreous kinds frequently present a very dark purple hue. In western Minnesota and again in certain points of Dakota, there is associated with the quartzite the fine clayey rocks known as pipestone, or catlinite. Intermediate between this pipestone and the purely silicious quartzite are clayey sandstones and quartzites, often of a blotched appearance, and not a little resembling externally certain of the Keweenawan sandstones of Lake Superior. So far as the microscope studies have gone these rocks are in the main mixtures of red clay and quartz. Conglomeritic phases of the quartzite are met with at a number of points, but no other rocks but those already mentioned have been recognized in this great formation."

Thin sections under the microscope show that the great sandstone beds have become consolidated and rendered quartzitic through the secondary enlargement of the sand grains, by additions of silica, the added parts being oriented optically with the internal grains they surround. In South Dakota a few miles northeast of Carson station on the Sioux City & Northern Railroad, there is exposed in the railroad cut some sections which show an alternation of thin layers of the hardest quartzite and soft incoherent sands. In

places the alternating quartzitic layers are only one or two inches in thickness, and are each separated by several inches of loose sand. By selecting the sand grains near the quartzite and examining them carefully under a microscope, the grains may be found abundantly showing secondary enlargement. In many cases the crystalographic faces are well defined, and the common hexagonal pyramid of typical quartz is found perfectly reproduced, each with a sand grain inside. In many instances the sand grain is especially well defined for the reason that red oxide of iron has filled the irregularities in the surface. It appears, then, that in these enlargements there is a more or less rounded irregular grain, thickly coated with iron oxide, and around this has been deposited secondary quartz with crystal faces often well defined. As the secondary enlargement goes on the contiguous grains become closely interlocked, forming the compact vitreous quartzite which is so well known.

ORIGIN OF THE PRESENT DRAINAGE SYSTEM OF WARREN COUNTY.

J. L. TILTON.

SYNOPSIS: *First.*—In Warren county the drift is of uneven depth. As in other drift areas, this unevenness is not dependent entirely on the pre-glacial surface. In the unconformity of the drift on this pre-glacial surface a relation is seen indicating a similarity between the present drainage system and the pre-glacial drainage system.

Second.—The present river valleys and larger ravines are larger than present streams require. They fit into the pre-glacial valleys.

Third.—In the smaller ravines only do we find erosion without regard to the pre-glacial configuration of the county.

In connection with field geology work in the northern part of Warren county and the adjacent townships of Madison county, a question of constantly increasing interest to me has been this: To what is the present drainage system of the county due? I will endeavor to make clear an answer to this query, without too much detail, leaving other questions to be presented at some future time.

It is generally understood that the drift is laid in irregular deposits, here thick on the hill-tops, there thick in the valleys. Are we to expect, then, that the present drainage system has been marked out since the "Ice Age," with little regard for the previously existing systems? It is true, that in the county referred to there is no regularity in the depth of the drift deposit. At times the drift rests on sandstone, at times on limestone, at times on shale.

Two-thirds way from Indianola to Spring Hill is a valley; its sides with equal pitch. The road down the east side shows Carboniferous outcrops

very prominently, while by the road down the west side is a drain, cutting deep into loess, without a trace of Carboniferous strata. A little east of this ravine is another ravine crossing the road, cutting through loess and various Carboniferous strata; here is an excellent illustration of unconformity, for within a hundred feet the surface of the Carboniferous strata slopes northward, in the direction of the present drainage, allowing the loess to rest successively on clay shale, coal, fireclay and shale.

Indianola is built on a hill thickly capped with drift, while a hill east of Carlisle has shale, clay, and coal out-cropping in the road, even near the top of the hill.

To see the bearing of these illustrations of unconformity, let it be remembered that the old surface was exposed to erosion during untold centuries from the close of the Carboniferous Age till the "Ice Age." In that long period there was opportunity to cut out the immense valleys occupied for ages then as now, by small streams. The unconformity of the drift on this ancient surface reveals the direction of drainage in pre-glacial times. This unconformity indicates that the more prominent ravines of the present lie in pre-glacial ravines, though frequently on one side of the ravine.

At present three rivers carry the surface water to the Des Moines. At times in the spring these rivers are filled till their flood plains are submerged, but ordinarily they are nearly dry. Making what seems due allowance for high water in spring, one cannot help but wonder how these streams could cut into Carboniferous strata or even wash away drift material till each little river had such broad flats as those to be seen north of Greenbush on North river, at Summerset on Middle river, and south of Indianola on South river.

Comparing the ravines that open into these rivers, we notice that where the surface rocks are least easily decomposed there the sides of the ravines are steepest and out-crops most easily found, while in sections where the surface rocks are soft, as north of Lathrop, there the sides of the ravines are rounded and out-crops less frequently found; yet over it all the loess is generally undisturbed. Some of these main ravines cut deep into loess, while the same deposits are apparently as deep on the knolls that separate parts of the ravine. Back from the main ravines reach the smaller ones, rarely cutting deep enough to remove anything but loess.

East of Buffalo bridge a valley nearly a quarter of a mile wide is cut through a hill fully a hundred and seventy feet high composed of masses of limestone, but the ravine mentioned now contains a stream nearly dry the larger part of the year. What little water there is in this gorge flows northward.

Comparing the valleys running to the north with those running southward there is nothing to indicate that one set has been favored more in its formation by either ice or water from melting ice masses. We should naturally expect ice moving from the northeast to gouge out the soft material lying on the north slopes near the tops of the hills; yet such material is still found exposed. At the unconformity mentioned where the ravine opens to the northward the strata referred to are very exposed to such erosion. The valleys sloping to the northward have no characteristics in common, distinguishing them from valleys sloping southward. Especially is it difficult to conceive how ice, or water from a melting ice mass, could erode such a

valley as that mentioned as lying just east of Buffalo bridge, Madison county, or of those in White Oak township, Warren county.

A similar statement may be made in regard to the river valleys. The rivers wander here and there over a partly alluvial plain with drift along the margins, at times even on the very banks of the rivers themselves.

Comparing these different data it is clear the river valleys were marked out chiefly in pre-glacial times. During Mesozoic and Tertiary times when this region was subject to constant erosion, wide valleys were cut into the carboniferous strata as deep as the present valleys. While the drift is an important factor in the present configuration of the country, yet in the region referred to the ice had little to do in erosion, and the waters from melting ice sought in general the natural previously determined drainage courses thus keeping open the rivers and many of the chief ravines of pre-glacial times, while only the lesser ravines have been marked out since the drift was deposited.

STRUCTURE OF THE MYSTIC COAL BASIN.

BY H. FOSTER BAIN, IOWA GEOLOGICAL SURVEY.

The lower measures of the Iowa-Missouri coal field consist of a series of sandstones, shales, fire clays and coal beds, which have been found to interlock in a characteristically irregular manner. The different individual beds have, with rare exceptions, only a limited extent, and frequently grade into each other in a manner making their stratigraphy quite complex. This variability has been recognized by many workers* and has recently been elaborated† so fully that only a reference is necessary in this connection.

The explanation of the irregularity is found in the conditions of the depositions of the beds. It depends primarily upon the facts indicated so abundantly by the nature of the beds themselves—that these measures are marginal depositions, and it has been suggested‡ that in this field the lower coal measures represent the marginal deposits, of which the upper coal measures are the, in part, contemporaneous open sea beds.

In certain portions of the field the irregularities may be directly traced to the influence of the uneven nature of the floor upon which the beds were laid down.

*Swallow: Rep. Mo. Geol. Sur., p. 87, Jefferson City, 1855.
Worthen: Geol. of Iowa, vol. I, p. 250, 1858.
Broadhead: Rep. Mo. Geol. Sur., II., p. 166. Jefferson City, 1872.
Norwood: Rep. Mo. Geol. Sur., pp. 200-215, 1873-1874. Jefferson City, 1874.

†Keyes: Stratigraphy of the Carboniferous in Central Iowa; Bul. Geol. So. Am., II., pp. 277-292, 1891.
Winslow: Mo. Geol. Sur., Prelim. Rep. on Coal, pp. 21-22, 1891.

‡Winslow: Missouri Coal Measures and the Conditions their Deposition; Bul. Geol. Soc. Am., III., 109-121, 1892.
Keyes: Geol. Sur. Iowa, vol. I., First Ann. Rep., pp. 84-85, Des Moines, 1893.

The limitations of the various strata are perhaps more strikingly shown in the coal beds themselves than in any others. The few limestones known to occur in the Lower Coal Measures, such as that shown in the banks of Walnut Creek at Mystic, are of course persistent over wide areas. Certain of the sandstones, such for example as that exposed at Red Rock, in Marion county, attain a considerable geographic extent. The shales, however, and even more particularly the coal beds, usually cover areas quite limited. Indeed it is the exception to find a coal bed which can be traced more than a few miles at most.

In marked contrast to this general character is the coal seam at present worked in Appanoose and adjoining counties. As compared with the other coal seams of Iowa the extent of the one in question is quite exceptional. As nearly as can now be determined it extends over a distance of nearly fifty miles north and south and at least forty miles east and west. There is probably no other vein in the Lower Coal Measures of the State which extends unbroken over an equal stretch of territory. Not that it is now absolutely continuous over the whole extent, but that its identity may be accepted with considerable assurance.

A general section representative of the strata of this region taken from the record of several mines at Centerville is as follows:

		FEET.	INCHES.
17.	Soil, fine black	3	
16.	Clay, yellow	33	
15.	Clay, blue, containing boulders and fragments of wood, coal and limerock	30	
14.	Limestone	6	
13.	Shale, argillaceous, blue	3	
12.	Shale, argillaceous, red	11	
11.	Sandstone, soft with thin hard layers	8	
10.	Shale, argillaceous	10	
9.	Limestone, compact gray	3	
8.	Shale, bituminous pyritiferous	7	
7.	Limestone, usually bituminous "Caprock"	3	6
6.	Shale, firm bituminous	1	2
5.	Coal	1	8
4.	Clay-parting		2
3.	Coal	1	2
2.	Fireclay	3	
1.	Limestone (seen in the bluffs at Mystic)	2	10

The thickness and character of these different layers vary within certain limits, but the general features of the section may be considered as fairly constant. Other bands of limestone occasionally make their appearance, and the character of the shale is of course inconstant. The presence of numbers 9 and 14 is tolerably constant throughout the field. They are known respectively as the "Seventeen" and "Fifty foot" limestones from their general occurrence at about those heights above the coal. They may be relied upon as fairly accurate guiding marks, though they have in certain places been removed by later erosion.

An examination of the coal in the above section shows that it has several points which are peculiarly characteristic, and make its recognition easy and secure.

The following five sections are taken from different parts of the field, and are a few of a large number showing the characteristics of the vein. They

will show the main evidence relied upon to establish the identity of the seam, though much confirmatory material could be added from the nature of the coal and the general geological and topographical relations of the region:

(1.) Section measured as exposed along Walnut Creek at Mystic, in the north central part of Appanoose county:

		FEET.	INCHES.
7.	Limestone, massive, grey (seen in Lone Star drift)	2	6
6.	Shale, bituminous	1	
5.	Coal	1	6
4.	Fireclay		2
3.	Coal	1	
2.	Fireclay	1	3
1.	Limestone	2	10

(2.) Section as seen in a mine at Seymour, Wayne county, at a depth of 242 feet:

		FEET.	INCHES.
7.	Limestone "Caprock"	2	
6.	Shale, bituminous	1	6
5.	Coal	1	6
4.	Clay		2
3.	Coal	1	
2.	Fireclay	1	2
1.	Limestone bed-rock		

(3.) Section examined in a mine at Centerville, Appanoose county, at a depth of 150 feet:

		FEET.	INCHES.
7.	Limestone		
6.	Shale, black	1	
5.	Coal	1	5
4.	Fireclay		3
3.	Coal	1	2
2.	Fireclay	1	8
1.	Limestone		

(4.) Section at Blackbird Coal Company's shaft, two miles north of Unionville, Putman county, Missouri:

		FEET.	INCHES.
7.	Limestone, hard gray	3	
6.	Clayey gray shales (Clod)		6-8
	Black fissile shale	1	
5.	Coal	1	8-10
4.	Clay parting		1-3
3.	Coal		10-12
2.	Clay	3	
1.	Limestone		

(5.) Section of coal bed at Stahl, Adair county, Missouri:*

		FEET.	INCHES.
7.	Limestone	1	10-12
6.	Clay (Clod)		2-3
	Black fissile shale	1	6-12
5.	Coal	2	
4.	Clay partings		1-3
3.	Coal	1	
	Clay		1-2
	Coal		1-2
2.	Clay	1	4-6
1.	"Bottom Rock"	1	6

*Sections IV and V taken from Missouri Geol. Sur., Prelim. Rep. on Coal, pp. 56 and 61 Jefferson City, 1891.

An examination of these different sections shows a remarkable persistence of character. The thin clay parting remains constant between two and three inches over the whole distance. The greatest variation is shown in the underlying fire clay and overlying shales.

In Iowa this coal has been found along both branches of the Chariton river in the northeastern part of Wayne county, and mined near Grffiinsville and Milledgeville, in the northwestern part of Appanoose county. Its presence on Little Walnut creek, near Walnut City, is known. It is well exposed along Big Walnut, and is extensively mined at Brazil, Mystic and Rathburn. It has been mined at Plano, Garfield, Dennis, and a few miles southwest of Moravia. There is a coal exposure on Soap creek, at Foster, in Monroe county, which may be the same. At Centerville, Numa, and Jerome, the coal is mined at depths of about one hundred and twenty-five to one hundred and sixty feet, while at Seymour in Wayne county, it is reached at two hundred and forty-three feet; and at Howard, in the same county, is reached at a slightly less depth. At Livingston and Cincinnati, in the southern part of Appanoose county, it lies nearer the surface; near Hillstown, in the southeastern part of the county, it outcrops along the Chariton. Coal is mined at Coatsville, in Schuyler, Stahl, in Adair, and Mendota, Unionville, and other points in Putman counties in Missouri, which has been considered* to belong to the same seam, and part of it at least, has been directly correlated† with the Mystic coal. Without doubt this is a continuation of the vein mined in Iowa; since the mines at Cincinnati, Iowa, and Mendota, Missouri, are only a short distance apart, and the same is true at Hillstown and Coatsville. The character of the coal, and the attendant strata, as well as the general geological relations in the region in question, all bear on this assumption.

The presence of a seam of coal with such exceptionally uniform character and wide geographical limits within the boundaries of the lower coal measures as now recognized, is an item of considerable economic, as well as scientific interest. It has had a very important bearing upon the development of the coal industry of that portion of Iowa, and has been one of the leading factors in the remarkable growth which that industry has there experienced.

SIGOURNEY DEEP WELL.

BY H. FOSTER BAIN.

During the summer of 1888 a deep well was drilled at Sigourney, in Keokuk county. Captain Parker, who was at that time mayor, carefully preserved samples of the different strata passed through. These samples have recently been re-examined, and form the basis of the following notes.

*Winslow: Geol. Sur. Mo., Prelim. Rep. on Coal, pp. 54-62, Jefferson City, 1891.
†Norwood: Rep. Mo. Geol. Sur., 1873-1874, p. 295, Jefferson City, 1874.

While the unreliability of records derived from the ordinary or churn drill is fully recognized, it is believed that the care with which these samples were selected and preserved, at least considerably reduces that element of doubt. Previous accounts of this record have been published in the local newspapers, and re-published by C. H. Gordon in the *American Geologist.** Recent studies in the region, as well as a revision of the material, give, however, considerable information not available at that time.

The following table represents the record as recently determined, as well as the interpretation:

1- 98	Earthy matter	98	Drift......... 98
98- 120	Limestone, impure, earthy	22	
120- 135	Limestone, cherty	15	
135- 155	Shale, calcareous	20	
155- 165	Limestone and shale	10	
165- 170	Limestone, hard, bluish gray	5	
170- 187	Limestone, cherty, light	17	Saint Louis... 89
187- 189	Shale	2	
189- 314	Limestone, hard, white with brown particles	125	
314- 315	Shale, dark green	1	
315- 356	Limestone, grayish white to drab, *Rynchonella* at 342 ft.	41	Augusta.....168
356- 554	Shale, soft, green	198	
554- 556	Limestone	2	
556- 585	Shale, soft, green	29	Kinderhook.229
585- 835	Limestone	250	Devonian....250
835- 865	Sandstone	30	
865- 871	Limestone	6	Niagara 36
871-1030	Shale, blue argillaceous	151	Maquoketa..151
1030-1275	Limestone	245	
1275-1281	Shale	6	Trenton and
1281-1315	Limestone	34	Galena 285
1315-1430	Sandstone	115	Saint Peter..115
1430-1717		287	
1717-1888	Limestone	171	Oneota.

A comparison between this and the previously published record shows several discrepancies. The drift is in both cases given as 98 feet deep. The next 89 feet is now referred to as the Saint Louis, whereas it was formerly considered to be Keokuk. There are a number of reasons for this change. In the first place, an examination of the samples shows that the beds are not a single homogeneous limestone as represents the Augusta of this region, but are made up of alternating bands of limestone and shales such as compose the Saint Louis. It is also worthy of note that the particles of limestone preserved are of the fine grained, compact character and ash to brown color so constantly seen in the Saint Louis of this immediate region, and not of the coarser crystalline variety shown in the nearest exposures of Keokuk.

The topographic features also bear out this assumption. A line of levels shows that the mouth of the well is 118 feet above the bed of the river two miles south of town. Saint Louis limestone is exposed along the river, reaching here a height of nearly twenty feet, or about what it would be if on a level with the strata found in the well, which are referred to the same age.

*Gordon, Notes on the Geology of Southeastern Iowa (Am. Geol., IV, 237-239, 1889.)

Keyes* has recently shown that the two limestones found in southeastern Iowa, and long known as the Keokuk and Burlington, are really conformable members of the same formation to which the name Augusta has been given.

Worthen,† in his notes on Washington county, calls attention to remarkable thinning out of the Keokuk; it being greatly reduced or entirely absent over the regions studied. This observation has, during the present field season, been completely substantiated, not only for Washington, but Keokuk county. These facts taken together, all point to the same conclusions: that the first 89 feet of limestone pierced belongs to the Saint Louis, while the Keokuk is represented merely in a few feet of the succeeding 168 feet of strata. The two bands of heavy limestone comprised in the strata thus referred to, the Augusta, are closely similar in lithological character, and resemble the Augusta limestone of the region as nearly as can be determined. At a depth of 342 feet a fossil, Rhynchonella sp. und., was brought up, it being the only fossil preserved. Below this point the element of uncertainty becomes greater. The succeeding 229 feet of shale is probably all referable to the Kinderhook, though the thickness is somewhat greater than an examination of the Washington county outcrops seem to indicate. The 250 feet of limestone which succeeds is most probably Devonian. The succeeding 30 feet of sandstone and 6 feet of limestone are more probably Niagara, since Calvin has shown that the Niagara at Washington is arenaceous. It is prossible, however, in this case, that the sandstone encountered may be of Devonian age and represent the Montpelier sandstone. The overlying limestone being the Cedar Valley.

The Maquoketa shale seems, by comparison with neighboring records, to be well recognized.

The heavy limestone band, 285 feet, succeeding the shale is probably representative of the Trenton and Galena, though it seems impossible to draw a good line between them.

The 115 feet of sandstone which succeeds seems to be the Saint Peter. Beneath this for some distance no samples were obtained as the current of water struck was so strong as to wash away all the drillings. The lower position of the well yielded samples which an examination proved to be limestone as Gordon surmised, and not sandstone as published. This seems to clearly prove that the well ended in the Oneota, though the top of the formation was not definitely located nor was it penetrated, so that its thickness under this portion of Iowa is as much a problem as ever.

The well was sunk in hopes of obtaining strong flow of artesian water. A moderate flow was obtained but has never been used to any great extent. At 1,320 feet in the Saint Peter sandstone a vein of water was struck which contained mineral matter and possessed a strong odor. At 1,360 feet in the same formation an opening was struck and the drill suddenly dropped two feet. A strong current of fresh water carried off all the samples and the water increased to the depth of 1,388 feet, when it flowed over the top of the well while drilling and stood within thirty feet of the top when the drill was at rest. No more water was struck from here to the bottom of the well.

*Keyes, Geological Formations in Iowa (Iowa Geol. Sur. I, First Ann. Rep., 1892, 59-60, Des Moines, 1893).

†Worthen, Geol. of Iowa, vol. I, p. 244, Albany, 1858.

SOUTHERN EXTENSION OF THE CRETACEOUS IN IOWA.

BY E. H. LONSDALE.

The Cretaceous deposits of Iowa, from time to time, have received the attention of a number of geologists. The most important researches were made by Marcou, Meek, Heer, White and Calvin. Their investigations were carried on chiefly in the vicinity of Sioux City. The formation elsewhere in the State has, with a few exceptions, received no consideration. Its exact extent is yet to be determined; its vertical thickness is yet unknown; the relative ages of some of its beds remain to be established.

Over western Iowa, in fact, over practically the whole State, resting upon the pre-tertiary beds, whatever these beds may be, is a mantle of debris collected and carried by the great glaciers as they advanced and receded, then and in the end depositing that material which is now recognized as drift clays, sands, gravels and boulders.

This drift material, as a whole, commonly so extensive in vertical thickness, so persistent in its occurrence, and so readily yielding to the weathering agencies, has almost completely concealed the older rocks upon which it traveled and deposited itself. There are, however, occasional exposures of these rocks standing out more or less precipitously along preglacial streams which were of such magnitude or position, as the case may be, to withstand the attack made by the glaciers, and thereby continue their existence; along postglacial water courses which have cut through the drift and upper strata of the underlying formations thus developing a narrow or broad channel and growing new exposures along its way. These few outcroppings afford about the only source from which reliable geological results can be gathered.

The Cretaceous, made up as it is of soft layers, such as sandstones, whose particles are commonly loosely or not cemented together, and beds of clay shales, would naturally suffer to a greater extent from the effects of the glaciers and weathering than would the limestones and other hard rocks of older formations. It would consequently be expected that the limits of the former would not now be even approximately the same as the original restriction of the Cretaceous in Iowa, nor, as nearly the same as are the boundaries of the earlier formations. Again, on account of the texture of the Cretaceous the exposures soon became covered with debris, even though at the close of the glacial period they were yet bare. Therefore, only rarely will faces of rocks be left to view. This is the case not only inland but along the bluffs of large and small streams.

White has probably given more attention to the inland exposures of Cretaceous than any one else. In addition to the Sioux City region he

described beds *in situ*, in Guthrie and some of the southwestern counties and set them down as Cretaceous. To those in Montgomery county, consisting of almost wholly of ferruginous grits, he gave the name Nishnabotna sandstone. The exposures farthest to the southeast were located in Guthrie county; the southernmost at Red Oak, Montgomery county. These are all described as outliers, the distance from the assumed eastern and southern limits of the main Iowa Cretaceous deposits, of which the Sioux City beds form by far the most important adjunct, varying from twenty to nearly one hundred miles. In individual size these outliers have been considered as only a few miles, perhaps one to less than twenty, in their greatest diameter.

During the field season which has recently closed a considerable amount of work was done in southwestern Iowa; additional information pertaining to the Cretaceous outliers in general, was secured; the southern limit was extended and conclusions pertaining to areal mileage of the different outliers have been drawn with greater or less satisfaction.

In the first place let the topography of southwestern Iowa be considered briefly. Eastward from the bluffs which are prevalent along the great flood plain of the Missouri or adjacent to the river itself the counties consist of gently rolling uplands, which rise gradually to a height of one hundred to two hundred feet above the near by waterways. The tops of the ridges between the usually parallel streams continue in their axial lines in an almost unbroken plane for many miles. The bottom, level land next to the larger streams varies in width from a few yards to one or two miles, this width depending largely upon the size of the stream which penetrates the low land. From the outer margins of these bottoms there rise gradual slopes curving smoothly to the upland drainage lines. Occasionally are found outcroppings of bedded rock in these slopes but they are in no wise extensive in any locality. There are, however, in western Iowa beds of the Coal Measures which are exposed, but rarely are any such beds exposed at a great distance above the streams near which they are situated. The top of many are but a foot or so above the water, others fifty or possibly more; but those approximating the former in extent predominate. In the vicinity of the Cretaceous outliers this is even so and such occurrences would undoubtedly indicate if not certainly prove that these inland streams have cut through friable beds of the Cretaceous and but only a few of the upper beds of the hard Coal Measures, that possibly not unfrequently has the former formation not been passed through by the streams now existing and some of the so-called outliers are connected and not separated as heretofore supposed. The fact that the drift, though omnipresent, in this section of the State is not excessively heavy, not heavy enough to hide precipitous limestone bluffs, if they be of considerable thickness, makes this state of affairs more plausible. This condition seems even more probable in parts of Guthrie county where the bottom lands are much narrower than those to the southwest. Again, it is quite possible that these outliers in Montgomery and adjoining counties extend farther northward and those in Guthrie county farther northwestward, towards the sources of and between the streams along which they lie; at the same time shortening the space intervening between the outliers and the present limits of the main Cretaceous body in Iowa. Although no positive information can be given in support of this theory, the exposures being few in number and only adjacent

to the streams, one must readily infer that this condition exists at least to a greater degree than heretofore accorded. It is a notable fact that between the Guthrie and Cass county outliers there are no exposures of bedded rock either of the Coal Measures or of the Cretaceous and it may even be that one or more of these outliers in the one county are connected with those in the other.

Further, as results of recent investigations, new or previously unrecorded, Cretaceous outcrops have been found; the southernmost deposits of this age are no longer confined to central Montgomery and northeastern Mills counties.

In Montgomery county along the western slope of the ridge lying adjacent to and east of the East Nishnabotna, Cretaceous beds were recognized by an almost continuous exposure from Red Oak, the locality where White claimed the southernmost Cretaceous existed, to the south boundary of the county. The character of the bed varies here from a fine white to brown non-firm sandrock to a compact pudding stone. This latter is composed largely of pebbles from one-fourth to one-half an inch in diameter, imbedded in a somewhat to quite siliceous limonite matrix. In some of these exposures are absorbed excellent samples of cross bedding. At Coburg, only one mile north of the south line of Montgomery county a bluff rises abruptly from the outer margin of the here rather broad alluvial plain. Near the base of this bluff is a bed of fine friable sandrock eighteen feet thick lying beneath a few feet of coarser sand, small pebbles occurring in bands, over which bed rests about ten feet from the pudding stone. This entire section presents an elegant cross bedded character. About half way between this point and Red Oak these same beds occur and are more fully exposed. The total exposed thickness of the lower sandstone is thirty feet while that of the overlying pudding stone is perhaps as great. This latter rock is very hard and firmer than any Cretaceous rock yet noticed in Iowa, and is quite persistent in this vicinity, withstanding to a great degree the eroding agencies, so preserving the under deposits.

Two and a half miles eastward from Coburg, on the county line a soft, Cretaceous sandrock rises above Ramp creek forming on the south side of the creek a perpendicular bluff twenty feet in height. South of this bluff, in Page county, small outcrops of such stone are noticed; some in the slope of the hill higher than the top of the bluff just mentioned. On the hill to the northward a well entered the sandstone at an elevation some higher than that of the top of the creek bluff. These facts go to prove that the thickness of the bed here is not much less than it is found to be in northern Montgomery county. The bottom of the bluff extends into the bed of the creek and only a short distance up the stream Coal Measure limestone crops out, with no perceptible dip in any direction, several feet above the water, indicating again the unconformability of the Cretaceous upon the lower rocks.

In Page county about one mile east of Essex (Tp. 70 N., R. XXXIX W.) the pudding stone such as described elsewhere, is found exposed along the roadside. Here it has about the same relative position above the East Nishnabotna as at points farther northward. This outcrop is only twenty miles north of the Missouri line and is decidedly the southernmost exposure of the formation recorded as existing in Iowa. South of this exposure

about five miles a well more than 300 feet deep was bored and no bed, definitely recognized as Cretaceous, was shown in the record; though it is possible that some of the upper clays there met were of this age. No samples of the borings were seen.

It must be remembered that the surface of the Upper Carboniferous at the incursion of the Cretaceous sea in Iowa was not regular; perhaps even more irregular and broken than the surface of the strata is to-day. Deep channels, gorges, depressions, and rises marked the entire surface. The Cretaceous as a shore deposit may have wholly filled these Carboniferous channels and hollows, spreading itself in great depth near the floor, or partly leaving protuberances and ridges of higher elevations uncovered. However this may have been, the friable Cretaceous was, after the time of its laying down, greatly modified both by the preglacial weathering agencies and the glacial grinding and corroding. During those stages new channels were cut, others more deeply corroded, many extending through the entire thickness of the formation; large areas were disturbed, only to be obliterated by the repeated advancement and retreat of the glacier, and the high and low points were alike mantled with drift debris. The southern and southeastern limits, would, since the glaciers traveled in a southeasterly direction, naturally be more altered than would other portions of this shore deposit, the original shore line would be wholly displaced and a new line, probably a number of miles northward, left to mark the present irregular boundary. Thus it may be seen that the Cretaceous is not one persistent bed everywhere of the same thickness with its boundary an unbroken line, and its character unvarying.

Now extending from some of the outliers noticed the topography presents itself, just as it appears at the outlier, sometimes for several miles in length. To cite a case, consider the outlier which is exposed at Coburg and in that vicinity. Here for several miles to the southwest, between the West Tarkio and the East Nishnabotna rivers the upland topography such as at Coburg, continues without any abrupt change. Again, while no Cretaceous has been noted as occurring between the East Tarkio and the West Nodaway rivers, the topography in Page county between these streams resembles, in many respects, that between those streams to the west, along which Cretaceous beds have been found in Montgomery county.

It would appear, therefore, from surface features of this county, that the upland between these four streams are made up largely of Cretaceous deposits covered only by a mantle of drift. If this is so, it is probable that in the two counties lying in the most northwestern portion of Missouri, along the northern border, and through the entire length of Page county, Iowa, will be found just such beds of Cretaceous age as occur farther northward in the latter State. Additional examination of the region at hand may bring out definite results and prove that Cretaceous beds do now in reality exist in the doubtful localities just mentioned.

In doing this work it must be borne in mind from what has been said, that because the topography appears so in any place it does not necessarily follow that under such topography rests the Cretaceous; the marginal shore deposits may have been so modified and the debris from the Ice age so unevenly laid down that the existence or non-existence of the Cretaceous can no longer be recognized by mere topographic features of the land surface.

Near Coburg the Cretaceous appears to be quite heavy, but if this formation is found to extend southward and into Missouri where no areas, however limited in extent, have yet been found, it would no doubt be quite thin unless in exceptionally rare cases, for towards the southern boundary of Page county the Carboniferous rocks are not infrequently found, where exposed, a considerable distance above the drainage line, the ridges are not more elevated above them nor the drift less thick upon the upland.

Just how far the shore line of the Cretaceous sea extended southward cannot definitely be figured now, but, considering the position and abundance of outliers to the south and southeast along the present border, the direction the glaciers advanced and the readiness with which the friable beds could be broken off and carried away, one can immediately conceive how this shore line and the main deposit have been extensively altered, and how the present southern boundary may be far northward of the southern shore-line of the then probably continuous deposit.

For the present, however, it seems desirable to call the exposure near Essex at least very near the farthest south any Cretaceous *in situ* exists in Iowa; realizing at the same time the possibility, if not probability, that such may yet be found southward and in Missouri.

The finding of Cretaceous boulders amongst the drift is by no means uncommon. At the foot of the Missouri bluffs near Henton, in Mills county, a number of irregularly shaped masses of pudding stone were secured. Those were quite similar to the bedded stone in some of the counties further eastward. Just across into Missouri from Blanchard, Iowa, on the bank of the West Tarkio is, in a cut recently made, a fifteen-foot bed of more or less clayey sandstone doubtless Cretaceous in origin but modified on being removed and deposited here by the glacier. It would not seem that this sandbed nor the pudding stone had been carried away any great distance from their place of original deposition but their sources are yet to be traced.

TOPOGRAPHY OF THE GRANITE AND PORPHYRY REGION OF MISSOURI.

BY E. H. LONSDALE.

When speaking of the Archæan hills of Missouri Pumpelly has likened them unto "an archipelago of islands in the Lower Silurian strata which surrounded them as a whole and separate them from one another." To one who knows this interesting territory with its isolated and grouped knobs hills and mountains of crystalline rocks standing out more or less prominently and dotting the broad expanse of more recent sedimentaries, this figure is an exceedingly happy one; one most admirably taken.

In order to appreciate the picturesqueness of the scenery there presented it becomes requisite that not merely a birds-eye view be taken but also to

look deeply and well into the mountains and vales, trace out the tortuous water courses as they have etched their tangled way through oftimes seemingly impenetrable measures and softer strata; to survey the streams and behold there the narrow chasms or gorges with mural escarpments which occur in irregular succession. Thus will the hidden scenery, the beauty of the landscape, sculptured by nature, be revealed.

The crystalline rocks of Missouri are for the most part porphyries and granites and are confined exclusively to the southeastern portion of the state. They occur southeastward, almost to the northern limit of the earthquake or sunken area of Missouri; they occur westward more than one hundred miles from the Mississippi, the nearest known outcrop to this stream lying less than twenty miles distant. If a quadrilateral with township lines be here drawn to include all exposures of Archæan rocks, it would contain about four hundred square miles; a circle drawn to surround these exposures would have a diameter of more than eighty miles. Yet the surface of either of these figures which is occupied by the crystallines is less than one-tenth of the total enclosure. Occurring in ten counties, they are more abundantly exposed in Iron, Saint Francois, Madison, Wayne and Reynolds counties. In the others the exposures are scattering and not unfrequently quite isolated. In fact, some of these isolated outcrops being quite low, not much, if any, above the general level, are found, perhaps, only by chance. These crystalline rocks are the oldest in the state. They stood long prior to the forming of the latter sedimentary rocks. After standing for ages as parts of the continental body, they now appear with sandstones and limestones originating from the degradation of this continent surrounding them.

The Archæan hills often occur in groups each separated by divides or valleys of the same formation or they occur as individual and grouped points separated by Lower Silurian or Cambrian beds. The distance from Archæan, across Cambrian, to Archæan, may be a few feet or twenty or twenty-five miles and the length or broadest diameter of the continuous crystalline areas varies to about this extent, though the great majority of these are much smaller than the upper extreme.

Made up almost wholly of the crystallines and other hard rock and void of any glacial drift, southeast Missouri abounds in excellent exposures of the beds there existing. Presenting such varieties of rock, frequently in occurrences somewhat singular, the attention of the geologist is ever attracted. Problem after problem has arisen and been solved, yet to-day the field is new; many problems of great importance stand out for solution.

In addition to the porphyries and granites here present there are large areas of sandstone, limestone, or limestone capped with chert masses and fragments. Each of these is represented by a type of topography entirely distinct from that of any the other formations. The valleys of the sedimentary rocks do not resemble the valleys of the crystallines more than the hills of the former the mountains of the other. Of course in some places the type may be less characteristic than in others.

To the east of the southern limit of the crystalline region the elevation of the Mississippi river is approximately 300 feet above sea level. The highest certained altitude of the Archæan hills is 1,800 feet whilst the greatest eleion of the Cambrian hills is about 1,700 feet. Of the former the porphyry s are the highest; of the latter the chert-capped limestone ridges are more vated, consequently more conspicuous.

The well known higher porphyry mountains may frequently be recognized many miles away; their position, and consequently name, being readily detected, owing to the peculiar or distinct topographic features characteristic of the individual mountains. Famous Pilot Knob and its neighbor just across the valley of Knob creek, Shepherd mountain, are excellent examples of such forms. In the case of the former it is especially so, for, besides standing out a rather sharp, conical mountain, singular in form it is also marked by the deep cut from which iron has been mined for years which extends almost to its summit. Although this mountain is not so high by nearly 300 feet as some others, the distinctive form which it possesses together with the artificial cut makes its recognition doubly easy.

In the extreme southeastern portion of the State extending northward from the Arkansas-Missouri line and westward from the Mississippi river lies what is known as the earthquake region. This is now a rather extensive territory composed for the most part of lowlands, swamps and marshes. The lowlands commonly rising not many feet above the "Father of Waters" on the east are of Tertiary and Quaternary age. Grading seemingly somewhat gradually on the west on account of the contact with the low or bottom land naturally approaching the waters of the Black river, and quite abruptly on the north, the topography of the swamp region stands in marked contrast with the rough topography of the Archæan and Cambrian hills; the first with far separate contours and sluggish streams, the last with a magnificent drainage, high hills and narrow valleys.

As has been said, each formation in distinct area, whether it be porphyry, granite, limestone, sandstone or a combination of two or more of these will have its own special type of topography, each peculiar in itself as well as when compared with others. So by means of the topographic maps one can ordinarly discern the formations represented thereon.

Whilst in territories of limestones and sandstones the number of streams possessed by each is nearly the same, such may be said of granite and porphyry fields; but the number of larger streams and stream-ways in the Cambrian greatly exceeds the number in the Archæan. The streams in the former are more tortuous, the channels considerably wider and the flow less rapid. This is all largely due to the great difference in the texture of the rocks of the two geological formations, the comparative softness of the sedimentaries augmenting erosion. What is but a dull drainage line in the crystallines becomes, in a corresponding period, a well marked ravine in the sedimentaries.

The regularity with which the Archæan streams have been and are being formed depends primarily upon the form of the upland. If it consists of hilltop after hilltop the streams or gullies will be more common and more strongly marked than if the summit is not pointed, but is a narrow or wide plane of some length.

The limestone areas in southeastern Missouri are of two kinds; the common is the irregularly broken ridge with a crest having about the same level, from which extends more or less successively, often for a considerable distance, points or spurs of various lengths. Nearly the whole surface is covered with detritus which consists mainly of chert fragments often coated with drusy quartz. These ridges made up for the most part of the Magnesian limestones in heavy ledges, are only recognized as bearing such by

occasional out-croppings of the same at the base and on the slope at variable altitudes. The topography of this country is rather simple and in a way monotonous, yet somewhat difficult to map on account of the numerous protruding spurs or points. The contours appear near the base rather far apart; toward the summit they run closer together and at nearly regular intervals until the topmost contour is reached, when a break in the regularity is occasioned. Here when the interval is as great as twenty feet the line frequently extends perhaps a mile or more with little curvature, both sides parallel with the axis of the ridge. When these chert-covered areas are more limited in extent hills rise as individual points separated by synclines whose troughs are of nearly the same level. In this case the regular contouring is unbroken from base to summit.

The other limestone regions are recognized by gently sloping fields capping the heavily bedded stone which, upon decomposition gives rise to the dark red coloring prevalent in the soil above and the associated clay. The larger streams traversing a region of this character leave banks of roughly weathered rock and but little detrital material; along the smaller ones bedded rock is seldom exposed.

There is presented in a region distinctly of sandstone a barren, for the greater part level, area cut by ravines, one or both banks being of solid sandrock ofttimes left in overhanging ledges by the eating out of the under portions of the bed. Along the nearly level tops, outcrops of sandstone are frequent, as the overhanging soily material, which in time accumulates does not form a mantle of equal thickness over the surface of the stone, but being of a coarse, sandy nature, is transferred from place to place and collected in heaps leaving other portions bare.

Over southern Missouri the limestones and sandstones are so closely, albeit irregularly, associated that their mode of occurrence, extent and relative position in the geological scale has long been a subject of discussion. Here there are extensive regions where both kinds of rocks prevail. Outcrops are common; first one then the other appear, over-lapping and interlocking. The problem of classification becomes intricate. The general surface features of a combination of the two sedimentaries are not like those of either alone. However, the type exhibited is but little more than a combination of the types represented by the rocks separately.

The topography of the Saint Francois mountains, this name having been applied by Winslow to the porphyry and granite hills and mountains of the region in question, is indeed striking, much more so than is that of the Ozarks to the west.

These Archæan mountains stand out in bold relief among the knobs of the Cambrian. Where both occur the beauty of the relief maps is greatly enhanced by the presence of narrow gorges and steep acclivities which not uncommonly form solitary high peaks of conical form, which are surrounded on all sides by lower lands of the Cambrian.

Porphyry makes up by far the greater portion of the 400 square miles of crystallines. The style of topography although varying is impressive, and in not a few instances at all similar to that of the granite. But as a whole, the type which represents either rock will almost invariably prove itself strictly characteristic of the ancient rocks. The nearest approach to the porphyry type is that of the chert-capped limestone hills previously men-

tioned. These occasionally do resemble in outline the lower pointed porphyry knolls, though the angle of slope is commonly greater in the latter and the contours less sinuous.

From the sandstone and limestone uplands great hills of granite or porphyry not unfrequently ascend abruptly to diversified heights. Often do the sedimentary rocks almost completely conceal the crystalline. In other cases the stratified rock now extend only a short distance up the hill and across the valleys and shallow divides.

As a rule the porphyry mountains are either pointed at the top or have a long, narrow crest, but occasionally large mountains have summits quite broad, grading into the steeper hillsides; Taum Sauk mountain, perhaps the highest in the region, is a good example of this form.

The contouring of these mountains is quite plain, yet distinguished in being as a whole different from that of other hills in this region. The angle of slope from base to summit is, of the larger mountains, almost constant, no matter whether this angle be small or great, whether the mountain top be pointed or narrow crested. Pilot Knob may again be taken as an example to illustrate the former and Buzzard mountain, adjoining the Knob on the north, to illustrate the latter.

Over the inclines of the steeper porphyry hills great blocks and fragments of the rock have accumulated as they weathered from the body mass. This detritus is often of great thickness and hides the solid rock except in case of almost perpendicular faces. Thus it modifies somewhat the otherwise rugged surface. Soily material is here commonly very thin, and vegetation is not abundant and the rocks are of slow decomposition.

Cañons are not unfrequent in their appearance over the Archæan region. They are found of variable lengths in the granite as well as in the porphyries. The many water-courses, in seeking an outlet, have cut through great bodies or hills of these excessively hard beds, which as yet confine the water to very narrow channels with more or less expansive precipitous walls, bare and rugged in outline. The beds of the streams are broken and waterfalls abound.

It has been mentioned incidentally that the topography of a granite field is essentially different from that of the porphyry. The porphyries, almost without exception, have an aphanitic structure, whilst the granites are often extremely coarsely crystalline and are, therefore, subject to much more rapid erosion, erosion on all exposed faces to about the same extent leaving a rounded surface in every case. Of the porphyry, weathering takes place not in decomposition of the surface, but by merely a separation of the stone into blocks and fragments along joint planes, in this rock always numerous whilst comparatively rare in the granite. Occasionally large blocks of granite break away along joint planes and, weathering, are transformed into huge boulders, which either remain on the solid rock bed or tumble into the streams at the foot of the mountain.

Granite mountains are commonly rounded at the tops and often the upper gently rolling surface extends over quite a large territory. They are of less height and may make up the greater part of a mountain whose highest point is of porphyry. The slopes are irregular and broken. To map (using compass, aneroid and level) with accuracy and detail, a field of granite must necessarily be traversed at frequent intervals, perhaps more so than is

required in the mapping of any other formation in the Archæan regions. Where cañons occur in the granite their walls are more rugged, less precipitous and higher than in the porphyry, and the waterways are broader.

Closely associated as they are, the crystallines and the Cambrian ledges exhibit the contact of the two formations in many places. In some portions of the region it is not uncommon to find sandstone more closely accompanying the granites; limestone, the porphyries. Dikes are found more commonly in the granite. Iron ores are found mainly in the porphyry, while the lead ore in the crystallines is confined largely to the granite.

Specimens from many localities show an almost continual change in the hue, if not in the texture, both of the granites and porphyries. Between fifty and one hundred hues are represented in the former, while in the latter about two hundred distinctly different hues are shown, each in the corresponding number of specimens collected.

Associated as a dike rock in the granite, olivine diabase is also found, making up a few areas of considerable size. These have a topography much like that of the smaller granite fields. Limited areas of so-called syenite occur; also other forms of crystallines, rocks which will not here be mentioned.

OCCURRENCE OF ZINC IN NORTHEASTERN IOWA.

BY A. G. LEONARD.

In the Upper Mississippi valley for a considerable period after the mines began to be operated much more lead than zinc was produced. It was not until 1860 that the latter metal came into market. Since then the zinc production has rapidly increased. During the ten years previous to 1882 the output of zinc more than doubled that of lead, while in 1889, according to the last federal census report the proportion between the two was as 13 to 1 for the entire region.

On account of their increasing importance the zinc deposits will be especially described in this paper, but as the two metals are so closely related in occurrence what is said of one will, in many cases, apply equally well to the other.

Not until the year 1880 were the Iowa mines worked for zinc carbonate or "dry bone," as it is called by the miners. Up to that time the carbonate, though found in many of the mines, was thought to have no special value and had been thrown away as worthless, or when found in the diggings the latter were abandoned.

In the fall of 1880 two wagon loads of zinc were taken to Benton, Wisconsin, by Mr. William Hird and sold for $16.00 per ton. So far as known this was the first zinc ore sold from the mines of the State, and from this time on the carbonate has been mined in rapidly increasing amounts. The

first mine to be worked for zinc was the McNulty, often called the "Avenue Top" mine, at the head of Julien avenue, Dubuque. This had previously been operated for lead and $25,000 worth is said to have been taken from it. The galena gave out in the crevice and a short distance beyond the zinc carbonate began to appear. It is estimated that this mine has yielded not less than $50,000 worth of the latter. After the sale of the first dry bone many began at once to search for it and numerous mines were soon being operated. Old lead mines that had been abandoned were again opened and worked for zinc when the associated ore began to appear.

A slight examination of the great mining regions of the globe will show that they are situated in regions of disturbance in the earth's crust. The strata have been more or less tilted from their original horizontal position, or are fractured and igneous masses intruded into them. In other words, the ore deposits of the globe conform to the general law stated by Humboldt that "the deposits of the precious metals and of lead, zinc, and mercury are usually associated with intrusions of igneous rocks."

The zinc deposits of the Upper Mississippi form a notable exception to the above law. They occur in practically undisturbed strata which show no evidence of having been subjected to metamorphic agencies or of having any connection with igneous masses.

The manner in which these deposits occur is also unusual. They are not in true veins, filling fissures produced by some deep seated cause and extending to a considerable depth, but the zinc is found in crevices which have a comparatively limited extent downward, and show no evidence of having been connected with igneous masses below.

Whitney says, in connection with the Upper Mississippi region,* "These deposits approach most nearly in character to what have been designated as gash veins; but they are in some respects peculiar in character, no mining region exactly resembling this in mode of occurrence of its ores, having been observed by me in any part of the world, unless it be in the Missouri mines in which the conditions of the Upper Mississippi region are closely imitated although upon a somewhat limited scale." In Missouri the zinc ores occur in the sub-Carboniferous formation. There is in that region an apparent connection between the surface drainage of the country and the deposits.

Other occurrences for zinc are those of Kansas, New Jersey, Pennsylvania, Tennessee and Virginia. The principal foreign countries for the production of this ore are the Rhine District and Belgium, Silesia, Great Britain, France and Spain, The first named region has for years yielded more than the other four combined.

The zinc ore of Iowa is found in crevices in the Galena limestone. The strata of that region are cut by fissures, and it is in the expansions or openings of these that the deposits occur. There is a very noticeable uniformity in the direction of these crevices. With few exceptions they have either an east and west or north and south direction, the former being much the more common. Besides these two sets there are others, known as "quarterings," that cross the main ones at varying angles. The larger crevices and those carrying most of the deposits are the east and wests, while the north and souths are narrow, and, when occurring in them, the ore is in sheets. The

* Wisconsin Report, vol. 1, 1862.

latter set in many cases serve as feeders to the major clefts, and at their intersection large bodies of ore are apt to occur.

The zinc as a rule is found in what are called "openings." These are formed by the widening of the crevices due to decomposition or solution of the rock in these particular layers. These cave-like expansions usually include a number of strata which form more or less irregular walls of either side. At the surface the fissures commonly appear simply as a seam in the rock, which followed down probably contains little or no mineral until it suddenly widens out into the opening where the ore, if any, will be found to occur. The dimensions of these openings are very variable, their height being all the way from three or four to forty feet, and their width from one or two up to twenty and in a few instances even forty feet. They are commonly limited above by a hard persistent layer of limestone appropriately called by the miners the "cap-rock." The latter is almost invariably cut through by a seam which may be so small as scarcely to be distinguished, or by an open fissure of varying width that often carries ore. The opening frequently extends up above the main level of its roof, forming large cone-shaped or irregular cavities or "chimneys" as they are called. On the other hand it may widen out and form large rooms or "caves" filled with the zinc ore.

It is not uncommon for the ore-bearing cavity to be divided or almost blocked up by a large mass of limestone known as the "key-rock." This obstruction has probably been left because of its greater compactness, that has enabled it to resist the destructive forces that have removed the surrounding rock.

The expanded crevices often contain rounded blocks called "tumblers," that, like the key-rock, have escaped decomposition, their edges and corners worn away by air and water.

The term "opening" is liable to be misleading as conveying the idea of an open space. They are, as a matter of fact, usually filled with ore mixed with more or less clay and rock fragments. Even where large caves are formed these may be filled to the top with crevice material mixed with zinc carbonate. On the other hand openings are found empty or only partially filled with clay, and can be traversed for hundreds and even thousands of feet through passages where no work has been done to clear the way.

The ore-bearing crevices, when followed down, are found to widen out into several openings, one below the other. The upper one is called the "first" opening, the next below is the "blue rock" opening of the miners, and still lower is a third and fourth. In the mines of the Dubuque region, the first is the only one that has been largely operated, the water hindering progress at the lower levels. The second has, however, been worked when possible. In the Center Grove mines, two miles west of Dubuque, ore has been removed from the third and, in one case, from the fourth opening.

The ores of zinc found in the Iowa mines are the carbonate (Smithsonite), sulphide (Sphalerite), and, in comparatively small amounts, the silicate (Calamine).

The carbonate or dry bone is by far the most common. It occurs in a great variety of forms; in cellular masses; as botryoidal coatings; in earthy masses and impregnating the rock. It is found coating galena crystals and also entirely replacing the lead and forming pseudomorphs. Several inter-

esting specimens were seen in which fossils had been replaced by the carbonate. One of these was a slab of dry-bone on which were several large gasteropods, their substance changed over into the zinc ore, which had preserved their outline perfectly. The carbonate will contain on an average 35 to 40 per cent of zinc.

The sulphide or "black-jack" of the miners is not found so abundantly in Iowa mines as is the Smithsonite. This is doubtless due to the fact that the former has been largely altered into the latter as will be explained later. The ore contains considerable iron and is so dark colored as to resemble the galena on a cleavage face.

The silicate is rarely found. When occurring it forms coatings on the the Smithsonite. Some specimens collected had a banded structure, and were not unlike quartz in appearance,

All the carbonate has without doubt been derived from the blende. Several facts indicate this to be the case: (1) It is not uncommon to find pieces, the outside of which are dry bone while the unaltered interior is composed of the sulphide. (2) In the lower levels and where it is below the water the ore occurs as the blende. This is the universal rule and would seem to be owing to the fact that the deposits beneath are not subjected to the alteration agencies at work nearer the surface.

The zinc ore may occur pure or mixed with more or less clay and rock. The carbonate is found coating the sides and top of the opening and covering the rock fragments in these. As before stated large masses of nearly pure dry bone occur filling large caves. In one of these great cavities the ore was so loosely deposited that a blow of the pick would cause tons of it to come tumbling down.

In their vertical distribution the lead and zinc ores of Iowa are unlike the occurrences in other parts of the region. Chamberlain makes the following statement concerning this:

"It is a law to which no noteworthy exceptions have yet been authentically reported, that lead predominates in the upper beds, but relatively decreases in the lower, while the zinc ores are very scant in the upper horizons, but relatively increase and often predominate below." This law does not hold good for the Dubuque region. There the zinc ore commonly occurs on the same level as the lead, and in some cases even above it. The zinc ore occupies the upper beds of the Galena limestone, few shafts reaching a greater depth than 120 feet, and then the upper portion of many is in the Maquoketa shales. It is doubtless true that the majority of the mines are in the upper one hundred feet of the Galena limestone, while in Wisconsin the zinc is confined mostly to the underlying Trenton. It often happens that the lead gives out in the crevices and, a short distance beyond, in the same opening, zinc ore will appear. Why the Galena should suddenly cease and the carbonate come in within a few yards, is a fact hard to explain. The two ores rarely occur mixed together, and where they are mingled the lead is in small quantities.

It will not be in place here to discuss at any length the theoretical questions connected with the zinc deposits. The subject is a difficult one, and sufficient data are wanting to prove, in a satisfactory manner, some of the theories advanced. But the questions connected with the origin of the zinc deposits are of much interest, both practically and scientifically and will

be stated briefly. They are best set forth by Whitney* and more recently, and in greater detail, by Chamberlain†.

First, then, as to the formation of the crevices. Extending east and west through the zinc region are numerous and abrupt undulations of the strata. These were caused by a horizontal pressure acting from the south resisted by a corresponding force from the north. To state it differently, the oscillations are due to lateral force from the Interior Sea to the south and resisted by the Archæan land area to the north. These flexures produced the crevices. As the strata were elevated the heavily bedded limestones were fissured parallel to the axis of elevation and more or less open crevices formed. In a direction at right angles little force was exerted and the beds were only fractured, producing north and south fissures.

As suggested by Whitney, the shrinkage of the rocks may account for some of the crevices, at least to their open character, though it is difficult to see how shrinkage could have the great influence attributed to it by that writer.

The ore receptacles having been formed, whence came the zinc to fill them? It will be necessary simply to mention here the rejected hypotheses, namely, those of sublimation, and of thermal waters. Facts are well nigh overwhelmingly against the idea that the fissures extend to any great depth, being confined chiefly to the Galena and Trenton limestones, and without such extension downwards either of the above theories are very improbable if not impossible. All the facts indicate that the zinc comes not from below, but from the limestones in which occur the crevices. It was deposited along with the sediments by the waters of the Silurian sea. The latter derived its metallic salts from the waste of the pre-existing land surfaces. Chamberlain describes in detail the cause of localization of the deposits to a few areas, ascribing it to the currents of the ancient sea, taken in connection with the precipitating agencies of organic matter.

After their deposition in the limestone beds the zinc was concentrated in the crevices by the action of drainage waters percolating through the metal-bearing beds. In this way the zinc was concentrated in the fissures where it is now found.

SATIN SPAR FROM DUBUQUE.

BY A. G. LEONARD.

Located less than six miles south of Dubuque and one and three-fourth miles due west of Massey station on the Chicago, Milwaukee & St. Paul Railroad are some curious "spar caves" as they are appropriately called. In these caverns are some occurrences of satin spar that are very unusual and of much interest. It is

*Geology Wisconsin, vol. I, 1862.

†Geology Wisconsin, vol. IV, 1873-1879.

doubtful whether there is another locality where such peculiar forms of calcite are found, two varieties being associated together in the stalactites. The latter have also undergone a change in structure since first formed. The caves were discovered by Mr. Baule, of Dubuque, while prospecting for lead. They are openings in the crevices of the Galena limestone like those in which the lead and zinc ores occur. Large and productive crevices have been worked less than a half mile to the north, and the spar-bearing fissures also carry lead at a lower horizon. Followed west out on to the high prairie land back from the river these crevices are marked by sink holes, and on a winter day the moisture is seen rising from them. The magnesian limestone of the region is cut by innumerable large and small fissures that at certain horizons form extensive openings that can be followed for thousands of feet, and form a labyrinth of underground passages. All the latter are formed by approximately east and west, north and south, and "quartering" crevices. The openings vary in size from those so small that one can scarcely force his way through, to others having a width of ten or twelve feet and height of five feet. Some are over forty feet in height.

These caverns are either empty or filled entirely or in part by clay. The deposits of lime carbonate occur only in certain portions of these openings where the moisture is most abundant. At these points the top and bottom are decorated with stalactites, stalagmites, and a wonderful variety of beautiful and fantastic forms. The passages are in places closed up by thick deposits requiring blasting to remove them. Strong currents of air pass through these caves and are doubtless instrumental in producing the curious formations.

In these underground passages two varieties of calcite occur.

1. Satin spar, formed of radiating fibers with silky luster. Colorless and white varieties both occur.

2. Argentine (Schieferspath). This variety has a pearly luster and is composed of more or less undulating lamellæ. Color, white. It agrees with the descriptions given by Dana and Tschermake for Argentine, and is to all appearances that variety of calcite. The latter author mentions it as occurring in Bohemia, Saxony and Cornwall.

Satin spar occurs in several different forms: (1) Includes those which are pearly white, on the surface of fracture and have a silky luster due to the radiating fibers that form a velvety surface of great beauty. This variety occurs in bunches or clusters of twisted and gnarled stem-like forms. (2) Includes those stalactites proper which are formed of radiating fibers. These have in cross section a subvitreous luster, but on the surface they are (a) either covered with a fine white powder (which under the microscope is seen to be composed of irregular grains or minute crystalline bodies), and have no luster, or (b) the outer surface is formed of little rhombohedrons and has a silky luster. These stalactites are white or colorless, opaque or translucent.

There are still other stalactites differing from any of the above that have a concentric, banded structure. These are of unusual interest. Beginning at the center they have (1) a crystalline or granular core, often showing bright rhombohedral cleavage faces; (2) a thin band of clay apparently wanting in some cases; (3) peary white lamellar calcite (Argentine); (4) band of clay; (5) fibrous calcite and (6) outer surface composed of little rhombohedrons. There are several points in the structure of these stalactites deserving special notice. They have not, as yet, been studied microscopically, as is hoped may be done later, but the following facts regarding them are reasonably well established. There is every indication

that the crystalline core was once fibrous, but this structure has mostly disappeared, especially in the larger stalactites and the rhombohedral cleavage has replaced it. In the smaller forms the transition from the radiating fibrous condition to the crystalline aggregate of rhombohedrons can be traced; the long acicular crystals become less distinct, but traces of them can still be seen after the rhombohedral form makes its appearance. Recrystallization has taken place and the particles have rearranged themselves to conform with the interior structure of the rhombohedrons; in other words, they are identical with the crystal form of the latter in all but external outline, and this has been prevented from developing, showing itself only on cleavage faces. A strong indication that this granular core was once fibrous is the fact that this is the common structure found in all these caves. The small forms all show the fibers, but as they increase in size alteration has taken place.

Another point of interest about these stalactites is the band of pearly, lamellar calcites occurring between the granular, crystalline core and the fibrous external layer. These white, undulating lamellæ form concentric rings in marked contrast to the radiating fibers associated with them. Occurring on both sides of the Argentine there is in most cases, if not in all, a thin band of clay. It is this that has doubtless stopped deposition for a time and the different variety was formed on account of the changed conditions.

The rhombohedrons forming the outer surface, while the interior is still formed of the radiating fibers, also deserve more than passing notice. They occur on the larger stalactites, not on the delicate branch-like forms. The outer surface of the latter owes its silky lustre to the innumerable fibers composing the surface. These frequently form delicate, cotton-like masses covering the outside of the satin spar. But on the majority of the stalactites occur the crystal aggregate of rhombohedrons. These may have have been deposited after the radiated interior was formed, but they seem to be due, rather, to the alteration or recrystallization of the fibrous mass, as in the case of the granular core. The conditions under which the fibers were formed have changed and there has been a corresponding alteration in the crystalline condition of the calcite.

If not the most interesting to the mineralogist, the white satin spar occurring in the large branch-like clusters is at least notable on account of its great beauty and rarity. It is difficult to give any idea of the rare and delicate appearance of these masses as they hang suspended from the roof of the caverns. At a distance they resemble white branching coral as much as anything. But near at hand the twisted and gnarled stems with their beautiful silky luster bear no resemblance to coral. The peculiar shapes assumed by these forms, differing so much from the ordinary stalactites, are no doubt due to the air currents moving through these passages. The wind coming now from one direction, now from another, causes the drops holding the lime in solution to be blown to one side and another of the slowly growing stem, the drop being held by the surface tension. The water does not trickle down undisturbed, as when forming the long straight stalactites depositing an even layer on the end and sides, but the carbonate is deposited for a time on one side of the branch and then, later, on another side. These clusters are extremely delicate and are removed with difficulty from the rock to which they are attached.

In these caves are found many large and fine stalactites and stalagmites. Some are short and stumpy, others long and slender. In one small opening

three by three feet the deposition of calc spar had gone on to such an extent that there was a deposit several feet thick on the floor, while hanging from above were numerous stalactites. These were arranged mostly in two rows along the sides of the cavern and touching the bottom or joining the stalagmites below they formed columns. The passage-way thus made resembles a miniature colonade.

OCCURRENCE IN IOWA OF FOSSILIFEROUS CONCRETIONS SIMILAR TO THOSE OF MAZON CREEK.

BY ARTHUR C. SPENCER.]

The wide celebrity of the fern-bearing concretions from the Carboniferous beds of Mazon creek, Illinois, attaches more than passing interest to the occurrence of similiar structures in the Coal Measures of Iowa.

These concretions are found in a small ravine near the Des Moines river, north of Dunreath, in Marion county. Careful search for similar concretions in the gullies of the neighboring streams has not been successful, from which it seems that the strata, which are cut by the streams in question, lie above their general level on a slight anticline. The other alternative is that the concretions are limited to a very small area, but from the relations of the overlying beds the first explanation seems to be correct.

The plant remains are found in nodules or concretions, scattered through beds of drab shale. These, when broken open, often display very perfect forms. Plant remains are not, however, present in all the concretions. Others are like small septarial masses and are filled with zinc blende.

The nodule-bearing shale is from three to perhaps ten feet in thickness, and of a light drab color. It rests upon an irregular layer of large septarial masses which, exposed in the dry bed of the stream, resemble roche-moutenees on a small scale. Above are shales in part bituminous and in part areaceous. Four inches of compact gray limestone, bearing fern impressions follows, above which is more sandy shale and a thin seam of coal which has been mined near by. The coal is about fifteen feet above the concretionary bed.

Many of the concretions have been washed out and are found already opened, but the best specimens are those recently exposed, which afford very perfect leaflets of several ferns. Among the forms identified were: *Neuropteris hirsuta*, *Neuropteris augustifolia* and *Annularia longifolia*. Others will undoubtedly be found when more material is examined.

EVIDENCES OF DISTURBANCE DURING THE DEPOSITION OF THE BURLINGTON LIMESTONES.

BY F. M. FULTZ.

In a general way the lithological characters of the Burlington limestones, including both the lower and upper divisions, are the same. It is true that some layers are more compact than others, some more massive and a few are even crystalline enough in texture to imperfectly resemble marble, yet they all owe their origin to the same source. The material comprising them is almost wholly crinoidal. To such an extent is this true, that, with the exception of a very few layers, it is scarcely possible to find a cubic inch of rock that does not show its crinoidal origin. There are a few layers of shales, clays, etc., but for the most part they are quite thin and form but a very small part of the whole. However, they are deserving of some attention and I shall take occasion to refer to at least one or two of them specifically.

What I will endeavor to point out in this paper is, that during the deposition of these limestones, there were some periods of disturbance. The evidences of such disturbance are: (1.) The more or less abrupt changes in fossil forms. (2.) Change in lithological characters. (3.) Erosion and unconformability. I wish to speak more particularly about erosion, but will first say a few things about the change in fossil forms.

I have already mentioned that the prevailing life was crinoidal. Not counting synonyms there are probably between 350 and 400 species of crinoids found in the Burlington limestones. The greatest number occurring in any one layer is not more than one-fourth of the whole; usually much less than that. Besides, many of these species do not lap over each other and there are several breaks where not a single species bridges over the change from one stratum to the next higher, without some difference in form. So universal a change in fossil forms would indicate a sudden change in climatic conditions, and since in each succeeding stratum there seems to be no diminution, either in number of species or individuals —the genera remaining nearly the same and the species closely allied to former existing ones—there must have been a comparatively early return to the former conditions. Of course, while all life may have been extinguished at one point, no doubt it flourished in full vigor at no very great distance away, and as soon as the conditions again became favorable it once more occupied its old ground. If the period of interruption was short, or the area of disaster not too widely spread, the new forms of life would not differ much from the old. But if the area of disaster was extensive or the period of interruption prolonged, then the result would show the extinction of species and the beginning of new ones. As a rule species do not gradually die out, *they are killed off*. At least this is the apparent fact if the

study of life is confined to a single locality. Of course to try to make the rule general would be to deny the theory of evolution. Since life is largely dependent upon climatic conditions, it follows that a sudden change in these conditions means a sudden change of life. So that, if in passing from one stratum to another, we find a considerable change in fossil forms, we must accept it as evidence of change of conditions under which the depositions took place.

Now, as I have already stated, we find such comparatively marked changes of fossil forms at several places in the Burlington limestones. Knowing such to be the case I have been on the lookout for further evidences of changes in the way of erosion, unconformability, etc.

It has generally been accepted that the deposition of the whole lower Carboniferous group in southeastern Iowa was uninterrupted. I quote from White, Geol. of Iowa, 1870, Vol. 1, page 202, "The accumulation of the strata which compose all the formations of the sub-Carboniferous group in southeastern Iowa, from the lower Burlington limestone to the Saint Louis limestone, inclusive, was evidently uninterrupted." And this seems to have been the generally accepted idea. White admits the change of fossil forms, but limits the changes to siliceous beds only, and advances the theory that life died out owing to the waters becoming charged with siliceous material. He makes no statement of the fact that some of the most distinct lines of change are at intervals between the lower and upper flint beds, and also below the lower one. It is most likely, too, that the flint beds mark *gradual* rather than *sudden* eras of change. However, of this I will say more later.

White gives 50 feet as the thickness of each division of the Burlington limestone, making 100 feet for the two. Now, at Burlington, the typical locality, the two together measure scarcely more than 50 feet. Of course there are deposits at other places in southeastern Iowa belonging to the Burlington series which are not represented at Burlington itself. And no doubt the complete section of the two divisions together would reach 100 feet. Now, while there was a cessation of deposit and corresponding absence of life in one locality, the rock building was steadily going on at other points not far distant. So that while 50 feet may be the maximum thickness at any one locality, the total thickness of the complete series might easily be 100 feet.

The lower division of the Burlington limestones gives a more continuous section than the upper. As to fossil forms there are some pretty distinct lines of change, but so far I have been unable to find any evidence of a corresponding era of disturbance. There is no positive evidence that there was a cessation of deposition The surfaces of some of the strata have a water-worn appearance, but no erosion has so far been discovered. It would not surprise me, however, to hear of such evidence having been found. The lower half of the lower division is well-bedded and seems to have been laid down in comparative quiet waters. The upper half is poorly bedded and contains many flint bands and irregular pockets of coarse sandy clay. It shows much disintegration.

As to the origin of these flint bands there has been a great deal of speculation, but so far no very satisfactory theory has been advanced. An examination of the beds will show that life did not suddenly cease with the advent of siliceous material. Frequently layers are found which are literally covered with fossils. My attention was first called to this fact by Mr. Chas. R. Keyes about two years ago while examining the Burlington limestone at Louisiana, Mo. I have since found it to be true at Burlington and other places. The fossils are always fully solicified,

although perfect in form and detail. Also they are usually very small, not exceeding one-fourth the size of individuals of the same species found in the associated limestone layers. So White's statement that the conditions seemed to have been unfavorable for the support of life, is true, at least in part. But I think the flint beds contain much more evidence of life than he has given them credit for. There is no doubt, however, that the flint beds of both the upper and lower divisions mark eras of change in fossil forms. It would be strange if they did not, considering that the minimum thickness of either is fully ten feet. But they do not furnish the most distinct lines of change inasmuch as some of those in the limestone takes place in passing from one stratum to the one directly superimposed.

In the upper division I have found direct evidence of disturbance and erosion at one of these lines of change in fossil forms. Everywhere in the vicinity of Burlington, where the upper division is found, there occurs, well down toward the base, a stratum of heavy bedded white limestone. It is about six feet in thickness and generally underlying it there is either a thin layer of blue clay or friable, yellow, sandy limerock. Immediately overlying it there is uniformly found a bed of tough blue shale. I had frequently noticed the upper surface of the limestone layer as exhibiting a water-worn appearance and so was not surprised when I found direct evidence of erosion. This discovery was made in the Cascade quarry in the south part of the city limits of Burlington. In this quarry nearly the whole depth of the Upper Burlington limestone is worked. The massive white layer spoken of is here between 5 and 6 feet in thickness and furnishes a goodly part of the rock taken out.

The Cascade ravine is about half a mile in length and enters the Mississippi river at right angles. These quarries are situated about a quarter of a mile back from the river and on both sides of the ravine. It was in the one on the south side that the discovery was made. This quarry is on both sides of a short, but deep, lateral ravine, the bottom of which is several feet lower than the stratum of white limestone. In working off the corner between the main and lateral ravines, the white limestone layer was found to be much eroded. The erosion is lateral rather than surface and occurs on the side toward the lateral ravine. The layer of blue shale is deposited directly upon the eroded surface and conforms to all the inequalities, some of which are quite abrupt. One bench of the eroded surface amounts to fully two feet and yet the blue shale covers this without a break. The blue shale itself is capped by well-bedded limestone.

This is direct evidence of erosion in the early part of the deposition of the upper Burlington limestone. An interesting fact is developed that the present drainage system was probably fixed at that early date. The position of the eroded surface of the white limestone layer, and the inclination of the directly superimposed beds all indicate that the lateral ravine had its beginning at a time at least as early as that. Of course the principal ravine must have existed to furnish an outlet. Along the banks of the principal ravine I have never seen the white limestone layer exposed, but have no doubt it would exhibit the same erosion as found along the lateral ravine. All the superimposed strata exhibit a decided inclination towards the ravine, which would tend to confirm the theory.

In conclusion, I would state that there seems to be no doubt whatever that the deposition of the Burlington limestones was not continuous. I expect to see other evidence of this fact discovered in the near future.

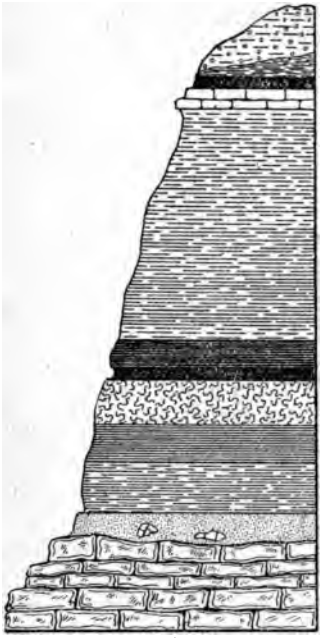
COAL MEASURES OF POWESHIEK COUNTY.

BY ARTHUR J. JONES.

Nearly all of Poweshiek county is covered by loess and drift to such a depth that little is known concerning the underlying stratified formations. Almost the only natural exposures of rock in the county are in the southwestern part where there are frequent outcroppings of Saint Louis limestone and Coal Measure strata; for the remainder of the county the only data obtainable are from wells sunk in various places. From these it appears that the northern, middle and eastern portions of the county are underlaid immediately below the drift with Lower Carboniferous strata. The Saint Louis limestone was found at Grinnell a little over 200 feet from the surface, while a little farther east the drift is still thicker with no indication of shale or coal. Coal has been found in paying quantities a few miles west of the county line in Jasper county at the Black Oak mine, and also a short distance from the south county line at the Evans mine. A direct line drawn from one of these mines to the other would cut across a considerable part of the southwestern corner of Poweshiek county. At Thornburg also, not far from the southeast boundary, coal mines are being operated. But although coal has been found on both sides so near, few workable veins have yet been found within the county limits.

At Searsboro two drill holes were sunk during the past summer and small quantities of coal were found not over ninety feet from the surface. Almost directly south of this place near Moore there are numerous traces of coal. Here the Saint Louis limestone appears for several miles along the north Skunk river. In the hills south of the river where they have been undisturbed, the Coal Measures are seen to lie unconformably upon the limestone. In a number of places in these hills prospect holes have been sunk but only a small amount of coal has ever been taken out. A short distance southeast of Moore, on the south side of the river, there is a fine exposure of limestone and shale. Here there is a bluff which shows over forty feet of Coal Measure strata with the Saint Louis limestone appearing at the base. At this place there are seen two seams of coal, the lower eighteen inches thick and the upper twelve. They are separated by twenty feet of shale and a thin layer of impure limestone which is only a few inches below the upper vein. Here a drift was at one time operated, and in a ravine near by considerable quantities of coal were taken out and sold to local trade.

The section at the old Petit mine is as follows:



Section near Old Petit Mine.

		FEET.	INCHES.
12.	Drift....................	5	
11.	Shale, argillaceous.......		6
10.	Coal		10
9.	Limestone, impure.......	1	6
8.	Shale, light colored above, getting darker below...	18	
7.	Shale, dark, bituminous, somewhat fissile	2	
6.	Coal	1	
5.	Fire clay................	3	4
4.	Shale, variegated........	3	
3.	Shale, light colored, calcareous.................	4	
2.	Sandstone, brown and yellow, with limestone nodules..............	2	
1.	Limestone, compact, brittle (Saint Louis exposed)	7	

But both mines have been abandoned for fifteen years, the larger coal seams near New Sharon receiving all the attention.

Farther eastward on Buck creek shale outcrops in numerous places, and a small vein of coal is also found. Drill holes put down in the neighborhood disclose several small coal seams, but none sufficiently thick for profitable working.

There have been various reports of coal both west and south of Montezuma, and it is probable that the Coal Measures occur here also, although probably quite thin.

In the southeast part of the county, near Deep River, three feet of coal have been found at a depth of 157 feet, overlain by seven feet of shale.

It is, then, highly probable that the Coal Measures extend over the entire southern tier of townships, including the towns of Searsboro, Montezuma and Deep River.

Systematic borings may yet reveal coal in paying quantities within the limits of this county.

CARDIOCARPUS IN IOWA.

BY ARTHUR J. JONES.

While engaged in geological work in Guthrie county a number of peculiar seed-like structures were collected from a seam of bituminous coal. They occurred in the newly opened mine of Mr. Scott, three miles northwest of Fanslers.

These seeds are not more than half an inch long and are quite thin. They are acuminate and vary from oval to broadly heart-shaped. At the base is a scar evidently indicating the juncture of the stem. No connection, however, was seen between the seed and the stalk of any plant in the coal. They are covered with a thin coating of pyrite and they all occurred in an eighteen-inch vein of coal.

Similar seeds are described by Lesquereux and Newberry as belonging to the genus Cardiocarpus and found in the coal measures of Pennsylvania, Ohio and neighboring states. The structures observed are evidently merely nuclei, although scarcely a trace of an encircling rim can be seen on any of them. The specimens collected are similar to the nuclei of Cardiocarpus bicuspidatus and C. zonulatus.

It is now generally conceded that the seeds called by the generic name Cardiocarpus are merely the mature fruit of certain species of Cordaites. The Cordaiteæ form a distinct order of gymnospermous plants very closely allied to the Cycads on the one hand and to the conifers on the other. They, however, bear a strong resemblance to the Lycopods and for some time were classed under this head. The living plant which most nearly resembles Cordaites is Cycas revoluta. . Newberry says that the fruit Cardiocarpus was probably somewhat drupaceous when living, the nucleus being entirely concealed, but compressed by the great weight of the overlying strata it has become flattened; the fleshy pericarp is now the thin membraneous rim, and the nucleus appears at the center, not so much crushed on account of its more solid structure, but somewhat flattened.

This fruit and other remains of Cordaites have been found in Ohio, Pennsylvania, Tennessee, Indiana, and various other states, but they have not been reported from Iowa.

NORTH AMERICAN CYCADS.

BY THOMAS H. M'BRIDE.

As is well known the Cycadaceæ constitutes a small section of the gymnospermous plants. They are therefore, related on the one hand to the *Gnetaceæ* or joint-firs, and on the other to the *Coniferæ*, the conifers, our familar pines, cedars, firs and yews. The Cycads are, however, both in habit and structure quite unlike in many ways, all other existent plants. Nevertheless the fruit is borne in cones as in the *Coniferæ*, and their stems, such stems as they have, are full of a gummy, resinous (?) sap, and the general structure of the wood, the disposition of the medullary rays also resembles these features in some of the coarser grained larches. On the other hand some of the Cycads, notably the species of the genus *Cycas*, resemble in some respects the ferns, their leaves unrolling from the stem's top are circinate in vernation. To Saporta Cycads have the appearance of small, low palms, the trunk is so short and massive, supporting its crown of far-spreading leaves. Again the roots of most Cycads are poorly developed and resemble those of the *Monocotyledones*. Accordingly, it may be said in a general way that Cycads are plants having leaves like the ferns, cones like the conifers, stems like the palms, and roots like lilies or grasses.

In days gone by these curious plants have been variously classified, accordingly as an author in his description laid stress upon this or that feature of the confused make-up. It must be said also in this general description that while most Cycads are as has been said simple low stumps a foot or two high, there are species, notably the Moluccan, that have tall and branching trunks forty to fifty feet in height.

The nature and habits of Cycads are fairly illustrated by *Cycas revoluta*, a not uncommon species in our greenhouses, and by our native American species *Zamia integrifolia*, of which more is to be said presently.

Miquel, a Dutch botanist as it appears studied the cycadaceous plants and published his work as long ago as 1842. Sir Joseph Hooker's descriptions in Genera Plantarum are drawn largely from Miquel's work. An abstract from Hooker (Gen. Pl.) is here presented for the better understanding of our subject.

"Flowers diœcious strobilaceous, Perianth always wanting. In staminate flowers the strobiles subterminal toward the apex of the trunk or caudex, generally solitary, oblong, ovoid or cylindric, very rarely subglobose; scales thick, coriaceous, alternately multiseriate, imbricate or vertically superposed and valvately united bearing on the dorsal side the polliniferous locules; these are arranged without order, three or four in a place, sometimes stalked but generally sessile opening by a slit and showing ellipsoidal pollen. The pistillate strobiles in *Cycas* have flat pectinate elongate scales bearing two or more ovules on the margin; in other genera the scales are shorter, more or less peltate, and bear one ovule on each side of the

narrowed base. The ovule is orthotropous and sessile; the seeds large, ovoid or oblong and usually fleshy and red outside but with a tough inner coat; the endosperm is thick, rather abundant; the cotyledons grown together, unless at the base; the plumule squamose emerging through a cleft in the cotyledons."

"Cycads are perennial plants abounding in gum, growing at the apex only, and as if corticated by the persistent bases of leaves and prophylla; the vascular system made up of rings of bast and wood, surrounding a well developed medulla or pith, which is rich in starch. Demarcation of annual rings does not appear and sometimes there are woody strands in the pith; the roots are fibrous and make up coralliform masses which are often partly above ground and sometimes by buds reproduce the plant."

Of existing Cycads there have been recognized some seventy species, of which the greater number occur in the tropics around the world. Some, however, are found in the temperate regions of South Africa and many in Australia and the adjacent islands. In Florida there is one species, as has been said, and one has been reported from Japan.

Our species *Zamia integrifolia* "Coontie" is a remarkable plant, having for stem a sort of subterranean bulb which has, however, a scarred cortex, a woody, cylinder and an abundant pith; large coriacious pinnately divided leaves which appear one after the other in a sort of a whorl, thus including leaves of different size, and for fruit shows cones of two kinds, staminate and pistillate, much alike although the latter is larger. Each cone is made of scales which are thickened, finally peltate, outwardly and bear at base the pollen-sacs or ovules as the case may be. The cones are not quite apical and they appear to spring from the axils of the leaves although this is not yet clearly made out and leaves and foliar organs are strangely mixed. In Cycas the cone is apical and subsequent growth starts up at one side of the cone's pedicel.

All this has been said of living or existing Cycads in order to make clear what may be said in reference to our North American fossil species. Saporta has pointed out very clearly that the ancient European Cycads (for there were once such plants in Europe although none there now) of which we have the trunks, do not differ from our modern forms much more than these now widely separated species differ from each other. "Fossil species are as a rule," he says, "far smaller than existing forms." A curious fact which leads to many surmises. For it must be said that the group under discussion as at present defined is but a remnant of a flora that from the Trias, probably, on down and through the Cretaceous shared with loftier plants all the forest regions of the earth, as these forests shifted through the ages from shore to shore, from zone to zone. Here in North America where now but a single species exists, persists, these remarkable organisms spread at one time from the Dakotas to Greenland, probably covering all that was then United States from Colorado to Maryland. As long ago as 1874 Lesquereux described from a single leaf fragment a species of Cycad which he named *Podozamites haydenii* from the Dakota sandstones of Nebraska. A few years earlier Heer in his *Flora Artica* described fossils representing at least four genera of Cycadaceous plants from the Atane Schists of Greenland. It speaks volumes for the wonderful botanical instinct of these men, that their conclusions, founded upon the study of mere leaf impressions and these often fragmentary were nevertheless accurate. These conclusions have since been wonderfully confirmed by the discovery of undeniable Cycad fossils in the regions and from the very formations and strata from which some of the leaf fragments came. While the ordinary

botanist finds sometimes on a single tree leaf differences enough for his confusion, these pioneers in Paleophytology have from the dim venation preserved in sand laid a sure foundation for our knowledge of the flora of the ancient world.

In 1878 Lesquereux described, from what he supposed tertiary beds, (since regarded as belonging to the Laramie group) a single species[1], and in 1883 he added six more from the Dakota sandstones; all as heretofore represented by foliar remains except the Laramie specimen, which is described from supposed fossil fruit. In the meantime, however, rather, far before, in 1859, so long ago, the state geologist and chemist of Maryland, Dr. Tyson, had found two Cycad trunks near Coontie station, on the line of the Baltimore & Ohio railway. Dr. Tyson seems not to have appreciated his find. He seems to have referred to the matter in his correspondence, and Rogers, of Pennsylvania, Uhler and others, have published references to the Maryland Cycads, but for some reason the fossils, strangely enough, were never described, never found place in our American geological literature. They lay in the museum of the Baltimore Academy of Science where still they lie, and so neglected were forgotten. We may be sure Lesquereux knew nothing of them, nor Hall, and not until Fontaine in 1889—thirty years after Tyson first saw the specimens—began the study of the Potomac beds for the United States Geological Survey, did these notable old fossils receive merited recognition and description. In volume XV, Monographs of the United States Geological Survey, Fontaine figures the Maryland Cycads for the first time, and so for science gives them at last "a local habitation and a name."

Fontaine unable, as he thought, to refer the specimens to any established genus, erected for the Maryland fossil a new genus which, in honor of Dr. Tyson, he called *Tysonia*, and has thus described it:

"Trunks varying considerably in shape and size, petrified with silica, more or less flattened; seen with the broader sides in front they are oblongate and truncate; in cross-section they are broadly sub-elliptical; medulla proportionately small; woody cylinder comparatively thick; cortical exterior layer with the permanent basis of the petioles very thick; basis of the petioles in cross-section normal sub-rhombic, or sub-triangular with the lower angle very obtuse; the outer angles acute and prolonged, the superior side forming a curved line bent upwards or forming an obtuse angle, but often from pressure distorted into irregular rhombic or triangular forms; trunks each with a large eccentric terminal leaf-bud, or growing bud; some of the trunks, probably of female plants, have numerous lateral buds; others, probably male plants, are without lateral buds, basis of petioles represented by open casts," etc.

Mr. Fontaine regards the Maryland forms as constituting a single species—*T. marylandica*. His new genus, he says, is intermediate between two genera established by Carruthers, viz.: *Mantellia* and *Bennettites*. Carruthers, on being shown a photograph of one of Dr. Tyson's specimens, said: It is obviously a *Bennettites*, and near *B. saxbyanus*. It is further to be remarked that Mr. Tyson's specimens are all badly weathered and worn, if we may judge from Tyson's figures. Still the macroscopic characters seem in the main plain enough, but the microscopic characters have never been looked into, at least never published.

In 1891, in the posthumous volume of Mr. Lesquereux's work,* seven additional species are added to the North American list, as before, all represented by leaf impressions.

Such was the state of affairs in reference to our North American Cycads down

[1] United States Geol. Survey of the Territories. Vol. VII.

*Monograph U. S. Geol. Survey, Vol. XVII.

to July of the present year (1893). That is to say, our North American Cycads were represented up to that time by one living species, about a score of fossil species from the Dakota group of the west, known to Lesquereux by more or less fragmentary leaf-casts, such species as Herr, of Lausanne, had described by leaf-fragments from Greenland, and Tyson's two trunks, silicified, but withal poorly preserved, kept in the museum at Baltimore.

In July of the present year the writer, being in Hot Springs, South Dakota, came across a handsome fossil offered for sale. The fossil proved to be a magnificently preserved, silicified Cycad. Some days later, on a bare hill, about thirty additional specimens were found in a more or less perfect state of preservation. Time has not as yet permitted a microscopic examination of the Dakota specimens, but all macroscopic characters are decidedly those given in Dr. Carruthers' definition of his genus. Our form is referred to a new species; for, while very much like *B. gibsonianus*, of Carruthers, it yet differs in the distribution of the leaves, as well as in the distribution of fibro-vascular elements of the leaf-petioles themselves.

That the Maryland specimens are also members of the genus seems, as already stated, most probable. It will be remembered that Mr. Fontaine, in his description calls attention to the flower buds bursting through the cortex, and to the elliptical section of the fossil. Mr. Fontaine claims two sorts of buds on the Maryland specimen but offers no microscopic sections in proof of the claim, besides his specimens it would seem are too far weathered to allow the exact determination of such points. These specimens cannot represent the genus *Mantellia* for in this genus the stems are globular. In fact, the Maryland and Dakota forms are very closely related—are probably species of the same genus and that genus is, in the writer's opinion, neither *Tysonia* nor *Mantellia*. Microscopic characters indicate two distinct species, but microscopic details as yet are lacking for definite and conclusive comparison. It is hoped later to offer the Academy the microscopic characters of the Dakota species.

For further details, descriptions and figures the reader is referred to the *American Geologist* for October, 1893, and to the *Bulletin of the Laboratories of Natural History*, volume II, No. 4, State University of Iowa.

RHUS TYPHINA LINN.

BY T. H. M'BRIDE.

(Abstract)

Rhus typhina is a northern plant, ranging from New Brunswick to Minnesota. It comes into Iowa in the northern counties only, being found in Allamakee and Clayton counties, but, so far as reported, nowhere else. The plant along the bluffs of the Mississippi river rises to a height of some thirty feet and has a stem at base six inches in diameter. It is a beautiful shrub or tree, differing, at sight, by its velvety branches and long-pointed leaflets, from the ordinary sumac (*Rhus glabra* L.) and well worthy a place in our dooryards to say nothing of a wider and better acquaintance. Where it prevails it seems to exclude the other species. I have never found *R. typhina* and *R. glabra* on the same hillside. That the plant should extend down the Mississippi river on the bluffs to McGregor and Lansing or thereabouts and not go farther south along the same stream is an interesting fact in connection with the problems of plant distribution.

BACTERIA, THEIR RELATION TO MODERN MEDICINE, THE ARTS AND INDUSTRIES.

BY L. H. PAMMEL.

It has been customary for the president, in making his retiring address, to choose some popular subject and discuss it on broad lines. In some cases my predecessors have given a resume of the scientific literature in our own State, and I need not say that we all feel proud of the work accomplished by this small band of workers. I shall venture, in this address, to discuss the subject of Bacteria along general lines and hope I may be able to correct some popular misapprehensions concerning the subject.

The word Bacteria has almost become synonymous in the minds of some with certain diseases in lower animals and man, but this popular construction is so erroneous, that I propose in this address to show the extent and importance of the question of bacteriology to many important problems.

We shall treat this question in the following way: History, methods of study, structure, question of species, hygienic problems, Bacteria and their relation to economic problems in agriculture and other industries.

We are told in an admirable treatise by Loeffler[1] on the historical development of bacteria that the presbyter, Kircher more than 235 years ago observed that air, water, soil, cheese and putrefactive substances contained countless numbers of "worms" as he designated them. Having observed these living organisms he at once concluded that the Italian plague of 1656 could be traced to these "worms;" but, the most remarkable of the early workers was Antony von Leeuwenhoek a mechanic of Delft, Holland, who had learned the art of making lenses while an apprentice in a linen factory. With his simple lenses and excellent powers of observation he was enabled to observe Bacteria of putrid material, tartar of teeth, etc. Some of the forms were figured and described. He says[2]: "Mit grosser Bewunderung sah ich, dass uberall in den genannten Material viele sehr winzige Thierchen enthalten waren, welche sich auf die ergoetzlichste Weise bewegten." From his figures and descriptions one cannot doubt but that he was dealing with bacteria. We cannot here give in detail the conclusions reached by Vallisneri, Goiffon, Nicholas Andry and Varro, but they concluded that these organisms caused disease. The celebrated Linnaeus[3] could not dispel from his mind that certain living organisms caused disease. The learned Viennese physician, Marcus Antonius Plenciz, discussed in a clear and logical way the cause of contagious diseases. He

[1]Vorlesungen ueber die geschichtliche entwickelung der Lehre von den Bacterien fur Aerzte und Studirende, Erster Theil bis zum Jahre 1878, 37 figures and 3 plates pp 252, Leipzig, F. C. W. Vogel, 1887.

[2]Loeffler l. c. p. 5.

[3]Loeffler l. c. p. 8.

argued that a period of incubation must occur for each disease, and as wheat seed only produces wheat, so too the particular seminia of a disease only produces that disease. He too argued that decomposition is brought about when sown with material, that this material propagates and grows.

In 1820 Ozanam wrote a learned dissertation on epidemic and epizootic diseases, in which he says it is not neceesary to show that the theories of Plenciz and others are purely hypothetical and erroneous. Notwithstanding that Ozanam doubted the correctness of the view of Plenciz on the contagious nature of diseases, others continued to carefully study the organisms of water, etc. Russworm designated them by their form, and, although he carefully studied them, this subject advanced but little. A host of scientists studied these so-called animals because it afforded great amusement. Little, however, was added till the celebrated Danish investigator, Otto Friederich Mueller, of Copenhagen, in 1776, made an exhaustive study of these so called Infusoria. He recognized the great difficulty in the study of these organisms, for he says "the certain and clear distinction of these requires so much time and sharp discrimination with the eyes, as well as excellent judgment and so much evenness of mind and patience that scarcely anything else equals it." He described ten species of the genus Monas and thirty-one of the genus Vibrio. He used such characters as motion, biological characteristics, Morphology and habitat. These germs were accurately figured so that it has been possible to recognize some of the species. But we must rapidly pass in review the work of Paula Schrank, who divided these vibriones into those with motion and motionless. Bory de St. Vincent placed these low forms in the family Vibrionides, deriving some of his characters from Auguillula. He recognized five genera.

SPONTANEOUS GENERATION.

The theory of spontaneous generation long held sway in the popular mind. During the middle of the eighteenth century the defenders of this theory promulgated their doctrines and for a long time the field was held undisputed. In this cause were enlisted such men as Needham, who observed the development of living organisms from grains of wheat and barley.

Although this material had been boiled and heated for a time and the vessel closed, still they developed. The arguments seemed impregnable and Buffon, and Wrisberg, Treviranus and others during the early decades of this animated discussion championed the cause of abiogenesis with a great deal of emphasis. During the fifties and sixties and in the seventies and even down in the eighties abiogenesis has had its defenders in such men as Pouchet, Joly, Musset, Wyman, Mantegazza, Huizinga, Bastian, and Wigand[4]. It is strange that the clear and logical thinker Wigand should, as late as 1884, assert that bacteria can arise independently without pre-existing forms from an organic substance *e. g.* spontaneously.

This, it seems to me, shows a lack of the proper methods of experimentation. Wigand had scarcely reached the stage of experimental work, where it was left by Spallanzani in 1769, who, as some one has said, was the most celebrated experimenter of that century. We may also mention Bonnet who was in thorough accord with this celebrated experimenter. With Spallanzani began the system of sterilization and making of tests to set aside spontaneous generation. It led Appert to utilize heat in the preservation of organic substances and has opened the way for glorious modern achievements.

Later investigators held that Spallanzani's experiments were not above criticism,

[4] Entstehung und Fermentwirkung der Bakterien vorlaufige Mittheilung, Zweite Auflage, N. G. Elwertssche Verlagsbuchhadulung, 1884, pp. 40 Seep. 5.

but they were fortified and strengthened by Schwann, who demonstrated that fermentation could not occur unless germs were present. The presence of these organisms was not denied. Braconnet (1831), Berzelius (1827) and Liebig, that brilliant, but conservative chemist, strongly held that these ferments simply accompanied the process of fermentation. Some held that the action of these ferments was entirely catalytic. Schwann, however, showed that various substances heated sufficiently under ordinary conditions will decompose, but if the air before having had access is heated, putrifaction did not occur. Schroeder and von Dusch were able to show that these precautions are not necessary, since a cotton plug will completely filter out all germs, and owing to this, which now seems a small matter, bacteriology has accomplished wonders in modern medicine and the arts. Hoffmann, Chevreul and Pasteur demonstrated that cotton is not essential for holding out germs. This can be done by simply drawing a tube out and bending it. As the germs simply follow the law of gravity they cannot enter.

In rapid succession the work of Pasteur, Klebs, Lister, Rindfleisch, Burden-Sanderson set at rest the theories of spontaneous generation. They are no longer advocated. All existing bacteria arise from pre-existing forms; so much is settled.

Bacteria are, no doubt, subject to the same general laws as to the origin of species as other living beings are; their growth and reproduction is determined in a measure by surrounding conditions. Bacteria are, no doubt, modified by climate and environment as are other living plants, but as yet we know little about this.

We may now ask, what are bacteria? Undoubtedly, plants amongthe lowest in the vegetable kingdom. In form, method of growth, and reproduction, they strongly resemble *Schizophyceæ*. Chlorophyll is absent. A few of the species described by Engelmann[5] and Van Tiegham[6] like *Bacillus chlorinum* and *B. virens* have Chlorophyll, and hence assimilate, but it may be doubted whether these forms are bacteria. They are, no doubt, closely related, and are important links in the chain of evidence showing the relation of bacteria to some of the algæ. With these exceptions they are fungi which do not form true hyphæ, nor do they make a true apical growth or branch; pseudobranching occurs in forms like Cladothrix. In shape bacteria are round, elliptical, rod-like comma, and spiral, sometimes growing in threads, and now and then certain aberrant forms. A peculiar group is found in Dr. Thaxter's[7] Myxobacteriaceae, which resemble Myxomycetes. "These consist of motile, rod-like organisms, multiplying by fission, secreting a gelatinous base and forming pseudoplasmodium-like aggregations before passing into a highly developed cyst-producing resting state, in which the rods may become encysted in groups without modification or may be converted into spore masses." Bacteria reproduce by division, the cell divides and two new individuals are formed. Many species form spores; these are usually of the endogenous character; a few form arthrospores, as in *Leuconostoc* and *Cladothrix*. In this genus we have the curious anomoly that *C. intricata*, Russell, branches like *Cladothrix* and forms endospores like *Bacillus*[8].

The cells are all provided with a cell-wall which appears to be made up of cellulose. Many of the species have motion, and this is in all cases probably due to

5 Bot. Zeitung, 1882, p. 321.

6 See Fluegge Mikroorganisms, p. 289; DeBary Bacteria, p. 4.

7 On the Myxobacteriaceæ, a new order of Schizomycetes, Contributions from the Cryptogamic Laboratory of Harvard University, XVIII. Bot. Gazette, vol. XVII., pp. 389, 406, with plates XXII.-XXV.

8 Zeitschrift fur Hygiene Vol. XI., 1891, p. 192.

cilia which may be numerous, coming from the periphery, as in Typhoid fever Bacillus, or several from the end, or a single one at one end of the extremities. Motion has recently been observed in a *Micrococus*. In some cases the cell-wall is extensible, some species are provided with a gelatinous envelope, the thickness and composition varies in different species. In some this sheath is a carbohydrate nearly like cellulose or in some putrefactive species, it is an albuminoid known as mycoprotein. In some cases these sheaths contain iron, other colors are sometimes found in the sheath, blue, yellow, red, etc., but it may be questioned whether these colors in all cases really belong to the sheath, although they do in some cases.

The contents consist of protoplasm which in some cases appears to be nearly homogeneous, but in a number it contains albuminoid bodies. In *Beggiatoa roseo persicina* it is colored according to Lankester[8a]. In *Clostridium butyricun* small refrigent granules occur that color blue on the application of iodine, in that respect they are similar to the granulose of starch. *Beggiatoa alba* and others contain highly refrigent granules of sulphur which are readily made out. Nucleus occurs as Buetschli[9] and others have shown. These authors believe that the nucleus is large. Minot[10] says, "This important discovery in conjunction with the extraordinary power of proliferation in bacteria confirms our generalization that a small proportion of protoplasm is essential to rapid growth." Koch, however, holds that the nucleus is not distinctly separated from the remainder of the protoplasmic mass.

Bacteria are among the smallest of plants, they vary in size from 0.0001 millimeter (Iu) or less, to 0.004 (*Bacillus crassus*) in width, length varies greatly. Bacteria are ubiqutous occurring in soil, air, water, ice, snow, dust, animals' plants. They are especially common in filthy and putrid substances; their use in such places is so important that we shall discuss this at greater length in the proper place.

SYSTEMATIC POSITION.

It will be seen from what has previously been said that the earliest investigators variously arranged bacteria. It seemed certain to them, that they were animals, for had they not motion? The learned Ehrenberg in 1838 ascribed to some, complicated digestive organs, owing to the way in which coloring matter was taken up. He recognized the division Monadina and Vibrionia.

We may now mention another systematist who still adhered to the animal nature theory: Felix Dujardin in his "Historre naturelle des Zoophytes," 1841, admirably figured the species in some cases, and it is worthy of note that this man observed that these "Infusoria" brought about certain chemical changes. He found that oxalate of ammonia which had been added to his culture material entirely disappeared when the germs had been growing in it for a time.

Perty, in 1852, indicated that some of these so-called animals were plants. Two years later Cohn published an admirable paper on the microscopic algae and plants in which he clearly indicated that the organisms in question were plants and not animals. Nægeli had previously recognized that some of the colorless forms found on algae were fungi, they did not assimilate like algae. In 1857 he brought all these forms together and called them Schizomycetes, a term generally adopted by bacteriologists at the present time.

8a Quart. Jour. Mic. Science, Vol. XIII, 1873, Vol. XVI.

9 Ueber den Bau der Bacterien, 1890.

10 Proc. American Association Adv. of Science, Indianapolis meeting, 1890, p. 284.

We may now briefly discuss the later classifications of bacteriologists. These begin with Davaine in 1868, who placed them in the following genera. *Bacterium*, *Vibrio*, *Bacteridium* and *Spirillum*. Hoffmann (1869) also adopted form as a leading character. He lays stress upon the fact that motility is not a good character, that this character may be absent or present depending somewhat on the conditions of the medium and temperature. As he was not dealing with pure cultures his observations in this respect are of little value. Ferdinand Cohn[11], of Breslau, who devoted himself largely to a study of bacteria since 1853 formulated and adopted an excellent system of classification which was largely followed, till better methods of culture were in vogue. Cohn's work made a profound impression on the chaotic condition of the science at that time. Cohn was too able an investigator to rely exclusively on the morophology of these organisms, for he states that germs cannot be separated morphologically, since they will show different chemical and physiological characters. He was not able to use many of these characters, since culture methods were very crude at that time. How far his predictions have held is only too well known to workers in this field at the present time. He made three groups—Chromogenic, Zymogenic and Pathogenic, characters which certainly find use in our present systems of classifications. Cohn believed that species of bacteria could be established just as well in this group of plants as in more highly developed organisms. The views of Cohn were not left unchallenged, for in 1874 Billroth published his researches on *Coccobacteria septica*, an organism which he obtained from milk serum. He argued that in different media the same species varies greatly; he says "es gibt bis jetzt Keinerlei morophologische Kennzeichen irgênd einer Micrococcus-cder Bacterien form, aus welcher man schliessen konnte, das-sie sich nur bei dieser oder bei jener Krankheit in oder am lebenden Korper entwickeln konnte." Lister, who has achieved such renown because of the introduction of antiseptic treatment of wounds, believed that morphological characters used by systematists from Ehrenberg's to Cohn's time were not to be relied upon, because he thought species changed in different media. Thus he held that his *Bacterium lactis* when grown in decoction of beets, urine and other media presented quite different morphological characters. In some media it had motion, in some it had not. He overlooked the fact that this single drop of milk contained many organisms. The accomplished bacteriologist, Buchner, at a much later day, thought *Bacillus subtilis*, a harmless species, could be converted under different conditions into *Bacillus anthracis*, a virulent pathogenic germ. Dealing with such small objects and methods of culture in vogue at that time caused a mixture of the two species. Is it to be wondered at that mistakes should have been made and wrong conclusions drawn?

We may conveniently now refer to the work of Hallier, a German botanist, who became greatly impressed with the work of DeBary and Tulasne on the polymorphism of higher fungi. Why should not this polymorphism occur in these small organisms? Luders had indeed advanced the theory that they were connected with higher fungi. Hallier constructed a culture apparatus in which his isolated germs were grown. Moulds of all kinds appeared, and the same common moulds appeared in widely different cultures. He concluded that the medium is the most important element in showing this polymorphism. He states that it is nonsencical to describe separate species of yeasts and bacteria with long names. His study of Asiatic cholera, diphtheria, glanders and other contagious diseases convinced him that they had their origin in a Micrococcus

[11]Untersuchung ueber Bacterien, Beitraege zur Biologie der Prflanzan, Vol. I., 1877, p. 127.

which was derived from higher fungi or algae. Many physicians and scientists were inclined to accept these wild doctrines. Was not the evidence good? Had he not the microscopical and culture demonstrations? Opposing these theories were two eminent botanists, DeBary and Hoffmann, the latter a strong believer in polymorphism, both were able investigators, the former one of the most brilliant botanists of our time. They held that species of bacteria could not be changed into higher fungi.

DeBary maintained that the first canon had not been observed, namely, watching the development of these forms. Hoffmann went so far as to state that polymorphism does not occur in bacteria. But we cannot close this part of the subject without referring to the work of Nægeli, an eminent German botanist and author of a celebrated work on "Die Niederen Pilze," who maintained that species of *Schizomycetes* cannot be defined by morphological characters.

DETERMINATION OF SPECIES.

For several years the writer has been studying the flora of butter, cheese, milk and cream. Many species have been found, and of these but few could be located, largely due to the inperfect descriptions; the chromogenes were much easier because more attention has been given to them and their color affords good characters. Saccardo[11] in his Sylloge Fungorum, gives descriptions of a large number of species. This work of De Toni is, of course, largely a compilation, the descriptions are largely abbreviated so that it is a hopeless task to properly or even approach the species. The tables of Eisenberg[12] are much more satisfactory, though even these are sometimes wanting in fullness. Nevertheless Eisenberg's tables are samples of what should be done in this line of study. The works of Flugge[13], Sims, Woodhead[14], Crookshank[15], will enable one to locate some of the more common species. Of special importance in this connection I may mention the paper by Edwin O. Jordan[15a] on the Bacteria of Sewage. The descriptions of the species found there are especially full. The paper by Welz[16] on the bacteriological examination of air, contains excellent descriptions of several species. A paper by Dr. H. L. Russell[17], on the bacteria occurring in the water of the Bay of Naples, is certainly a model in its way.

The imperfect descriptions of pathogenic organisms are not so numerous because of the importance of the subject from a hygienic standpoint. In some cases these contain many valuable notes on the biology of the organisms, as Kruse and Pansini[18] on the Diplococcus of Pneumonia and related Streptococci. The excellent papers of Dr. Theobald Smith[19] that are replete with biological and

---

11 Sylloge Fungorum, vol. VIII, pp. 923-1087.

12 Bakteriologische Diagnostik Hilfstabellen zum praktischen Arbeiten, second edition, pp. 159. Leopold Voss, 1888.

13 Die Mikroorganismen, mit besonderer Beruecksichtigung der Aetiologie der Infections Krankheiten, pp. 692, with 144 figures. Second edition, Vogel, Leipzig, 1886.

14 Bacteria and their products, pp. 459, with 20 photo-micrographs, London, Walter Scott, 1892.

15 Manual of Bacteriology.

15a A report on certain species of bacteria observed in Sewage. Mass. State Board of Health, 1890, Pt. II, p. 821.

16 Bacteriologische Untersuchungen der Luft in Freiburg und die Umgebung. Zeitschrift fur Hygieine und Infectionskrankheiten. Vol. XI, p. 121.

17 Unterschungen ueber im Golf von Neapel lebende Bacterien. Zeitschrift fur Hygiene und Infectionskrankheiten. Vol. XI, pp. 165-206, plates XII-XIII and three figures.

18 Unterschungen ueber den Diplococcus pneumoniae and verwandte Streptokokken. Zeitschrift fur Hygiene und Infectionskrankheiten. vol XI, p. 227.

19 Hog Cholera Report, 1889. Swine Plague Report, 1891, U. S. Dept. of Agrl., etc.

physiological observations. Dr. Sternberg[20] has also recorded a very large number of observations on the bacteria found in connection with yellow fever.

One of the most important works of its kind ever issued is Sternberg's[21] Manual of Bacteriology. This should be in the hands of every bacteriologist. The descriptions are so thorough that little more need be desired. Most of the species are easily identified by the diagnostic found at the end of the volume, while the descriptions are very thorough and complete.

CHARACTERS IN BACTERIA.

It is convenient here to discuss what characters should be used in the description of bacteria.

Those who have given any attention to the classification of *Schizomycetes* are aware that the work of purely systematic botanists like Winter[22], and Burrill's[23] translation of the same; Trevisan[24], DeToni, Cohn cannot be used or offer, in sufficient data, since morphological characters to separate species are not reliable. Many species are of the same size and shape. The species, however, seem to be quite constant in their morphological characters as shape and size do not appear to vary much within a species. Cohn[25] largely used shape and color in the determination of species, but this was largely pioneer work and many of the species defined by him cannot be recognized, and this is worse as we go back in the history of this science. Zopf[26] has been an earnest advocate of pleomorphism of species, and his classification rests on this doctrine. But pleomorphism is not so general as was at first supposed by Zopf. It is true that some species produce resting spores that resemble cocci as in Anthrax and other bacilli, but they never vegetate as such. But pleomorphism does exist in certain forms as in the group to which *Cladothrix*, *Beggiatoa*, and *Crenothrix* belong. These are truly pleomorphic, at least if we are to trust the work of those who have given the subject attention. In some forms, culture experiments have shown that a certain amount of pleomorphism does exist as in *Cladothrix intricata*, Russell. But in many cases the facts of pleomorphism have not been brought forth by culture experiments as was at first supposed. Frænkel[27] makes the statement that these organisms (*Cladothrix*, *Beggiatoa*) do not belong to bacteria, although they may be closely allied to them. "We may therefore maintain that, thus far at least a many formed species of bacteria has not been observed, and the rule one can distinguish by the growth and from clearly recognizable genera and species of bacteria, which do not run into each other."

Morphologically then, the different species are distinct, quite constant, although many species are similar. Our main reliance must be on physiological characters. And this is used nowhere else in the vegetable kingdom. Physiological characters are sometimes used in the classification of animals, as in the *Hexacorallinna*. The *Madroporiæ* secrete stony skeletons while the *Actinariæ* do not. In other

[20]Report on Etiology and Prevention of Yellow Fever, U. S. Marine Hospital Service. Washington, Government Printing office, 1890. See p. 181.

[21]A Manual of Bacteriology, pp. 886. Illustrated by heliotype and chromo lithographic plates and two hundred and sixty-eight engravings. New York, Wm. Wood & Co., 1892.

[22]Die Pilze.

[23]The Bacteria, an account of their nature and effects, together with systematic description of the species. Eleventh report Board of Trustees, Illinois State University, pp. 92-157.

[24]Genera e. Spec. delle Batteriaceæ, 1889.

[25]Beitraege zur Biologie der Pflanzen, Vol. II, p. 130.

[26]Die Spaltpilze, pp. 101 with 34 figures, Breslau, E. Trewendt, 1884.

[27]Text book of Bacteriology, English translation.

respects they are essentially alike. Prof. Osborn further calls my attention to the fact that in gall insects the character of the gall produced by the insect is of great importance in separating species.

I may be permitted in this connection to briefly quote from several prominent writers on this question. Trealease[28] summarized the characters as follows: 1. Morphological characters, mode of growth in which cultures show full range of variability of each species, behavior of cells to staining fluids, motion of the cells. 2. Physiological characters, production of pigment, specific fermentation and liquefaction of gelatin are apparently reliable. 3. Pathogenic characters for the most part are unreliable to render species which depend at all upon them above suspicion, though they may offer valuable collateral evidence. Any physiological characters therefore to be useful in the delimitation of species of bacteria, must be reasonably constant as well as pronounced. The fact is with our present means of cultivating bacteria, strictly parasitic, like the *Spirochœta* of relapsing fever; that it grows with great difficulty in artificial cultures, like the Micrococcus of gonorrhoea, that it dies after a short time when cultivated, unless re-innoculated like the swine plague bacillus of the Germans and our Department of Agriculture all the pecularities have at least a suggestive value." Fraenkel[29] writes: "Were the micro. scopical examination of the bacteria as they occur in their natural state, the only means at our disposal for studying them, our knowledge of bacteriology would never get beyond the experimental stage of certain very narrow limits." H. Marshall Ward[30] in an admirable article says that before new species are described the following points should be clearly made out: 1st. Habitat, air, soil, milk, etc. 2d. Nutrient medium agar, gelatin, potatoes, broth, saccharine liquids, etc. 3d. Gaseous environment, aerobic, anaerobic, whether carbon dioxide, nitrogen or hydrogen affect the growth. 4th. Temperature-optimum is the most important though maximum and minimum should also be recorded. 5th. Morphology and life-history, shape, size, mode of union, presence of sheaths and capsules, spores, endospores and arthrospores, cilia, involution forms, etc. 6th. Special behavior. Does the germ peptonize and liquefy gelatin? 7th. What is the shape and course of the area? What is the shape of the colony? 8th. Pathogenic properties. But before we can do a great deal in this line some general code should be adopted.

From these observations it will be seen that it is not an easy matter to recognize species; partial descriptions must be entirely ignored. I will admit with H. Marshall Ward that some general standard should be set up. But it would seem to me that we should soon begin to do something more on the biological characters of many species. Many of these points in our species are still in a somewhat uncertain state. They have, in fact, not been determined.

Much bacteriological work can be done with little equipment, but the systematic portion of this work can not be done without the literature at hand. To work out our bacteriological flora is needed, but it may be a long time before this work is accomplished. What is needed is a thorough scrutinizing of species to determine how many of these are synonyms. Marshall Ward[31] has attempted this for a good many of the species occurring in water, and he has what appears to me, placed together some species which are distinct. Marshall Ward is however, a most careful investigator, who discriminates with great care. This part of the work can

[28] The Weekly Medical Review, Vol. XIX, March 23, 1889, p. 315. St. Louis

[29] Text Book of Bacteriology.

[30] On the Characters, or Marks, employed for classifying the Schizomycetes, Annals of Botany, Vol. VI, No. XXI, April, 1892, pp. 103-144.

[31] Philosophical Transactions, 1892 or 1893.

not be done by a novice. I am greatly inclined to believe that many species have been described, as was true in many cases, of early systematic efforts with higher plants, without looking up the literature or carefully comparing specimens. It is out of the question in smaller institutions where library facilities are so meager that they should have access to much of the literature, and this is especially true where many of the species are described in out of the way journals. It seems to me that it would be expedient to describe species only in well recognized journals devoted to this line of work like Zeitschrift fur Hygiene, Centralblatt fur Bakteriologie und Parasitenkunde. The Botanical Gazette, Bulletin of the Torrey Botanical Club, or possibly the American Monthly Microscopical Journal might undertake to do this line of work on this side of the Atlantic.

BACTERIA AND THEIR RELATION TO THE DISEASES IN MAN AND LOWER ANIMALS.

The subject of Bacteriology has become so important in modern medicine that no physician can claim recognition as an authority in zymotic diseases unless he treats it from the standpoint of the modern advancement in this the newest of sciences. The author who ignores the facts of bacteriology can no longer find place as an authority in the library of a physician. Facts are being established however, so rapidly that even the best of works soon become obsolete.

Dr. Baumgarten says[33]: "In a study of diseases, the aetiology must not be considered by itself, when in this case we are dealing with organic beings——, bacteria and animal life, which bear certain relations to each other, the success in treatment cannot be controlled by a single factor."

Patrick Geddes[34], in that most charming of books, Chapters in Modern Botany, says: "Most important, however, is the fact expressed in the germ theory that bacteria are constantly and intimately associated with some of the most fatal of human diseases, such as consumption, diphtheria, small pox, or typhoid, malaria or leprosy. Bacteria, in fact, will kill most of us."

DeBary[35] says: "It is not necessary to enlarge upon the manifold interest attached to these organisms at a time when the statement urged daily on the educated public does not fall short of saying, that a large part of all health and disease in the world is dependent on bacteria."

So long as the old ways of looking at the nature of contagious diseases was in vogue, little could be expected, since it was before the advent of the cotton air filter by Schrœder and Von Dusch (1854) methods of sterilization, used by Schwann and others of his time, and perfected by Pasteur, Koch and modern workers, the use of analine dyes to stain bacteria, the introduction of culture media by Cohn, Pasteur, Brefeld, Schroeter, and the plate method of separating germs first used by Koch; these landmarks have, in a large measure, helped to give us a clear understanding and knowledge of the contagious nature of diseases.

We have seen that several authors believed that diseases like anthrax and cholera were supposed to be carried by specific organisms. In some cases, as in anthrax, Davaine had observed, in 1850, that the blood of anthrax animals contained stiff rods of the anthrax bacillus. Pollender observed the same rods in 1849. In 1863 and 1864 Davaine presented to the French academy the results of his innoculation experi-

[33] Lehrbuch der Pathologischen Mykologie Vorlesungen fur Aerzte und Studirende. pp. 973, with 108 figures, Harald Bruhn. Braunuschweig 1890, see p. VII.

[34] Chapters in Modern Botany, New York, Chas. Scribner's Sons, 1893, pp. 201, with 8 figures.

[35] Lectures on Bacteria, second improved edition, English translation by Henry E. F. Garnsey, revised by Isaac Bayley Balfour, pp. 193 with 20 figures. Clarendon Press, Oxford, 1887.

ments with the blood of diseased animals. It was also shown as early as 1865 that sputum taken from tubercular patients would produce tuberculosis. As yet, however, the evidence was not conclusive. In 1877 Koch published the results of his work on this disease, in which he showed conclusively that this special bacillus, which he had isolated from diseased animals and cultivated outside of the animal body, produced typical anthrax; that in the animal only the vegetative condition occurred, but when the animal dies these rods break up into spores; that infection in cattle and sheep commonly results from the taking up of spores while grazing in an infected pasture. The organism thus lives a dual life, one in the animal and one in the field.

In ordinary cultures, spores are readily formed and these retain their vitality for a long time. The writer has found that these when kept in silk threads retain their vitality for at least six years. We mention this disease in particular because it shows what rules must be followed in bacteriological research. The classic canons of Koch must ever be observed, and these are, first, constant presence of the germ with the disease; second, isolation and cultivation of the germ; third, successful innoculation experiments with the germ isolated, and followed by the same disease; fourth, this germ must be the same as in the original diseased animals. Dr. Russell[36] well says that these canons are just as applicable to phytopathology as in animal diseases. For my own part, I am sorry to say that so many bacterial diseases of plants have been described in which these canons have not been observed. But to follow through in detail the various stages of the history of this part of bacteriology, however interesting it is, would make this paper entirely too long. We shall therefore touch only upon the more important points.

Let us briefly consider the pyogenic organisms and their relation to septic infection. The lengthy disputes between different investigators on the subject of septic infection and the causal relation to the same and definite micro-organisms had a most excellent champion in Weigert,[37] who, in an able paper, set aside the generally accepted theories, that septic infection resulted from poisonous products of ordinary saprophytic germs, or that certain changes occurred in the body before the germs could develop. It was the old story of Justus von Liebig,[38] who strongly argued that germs and fungi follow a diseased condition. Weigert especially emphasized the importance of recognizing bacteria in different diseases. He should receive much credit for having done a great deal towards perfecting methods of staining bacteria.

The pyogenic microbes have been a rich field for investigators. For is not this subject of great importance to the physician? Almost daily he meets with the germs in question. They are concerned in such diseases as septicæmia, pyæmia and erysipelas. Then, too, these cocci are found in diphtheria. The forms of septicæmia occurring in lower animals are numerous, as Koch[39] first showed. A form of *Micrococcus* commonly placed in the genus *Streptococcus* is widely distributed in nature, and also produce septicæmia in lower animals. Dr. V. A. Moore has

---

[36]Bacteria in their relation to vegetable tissues. Dissertation presented to the Board of University studies for the degree of Doctor of Philosophy, Johns Hopkins University. Freidenwald Company, Baltimore, 1892; pp. 41.

[37]Ueber pockenaehnliche Gebilde in parenchymatosen Organen und deren Beziehung zu Bacteriencolnien, Breslau, 1875. See Loeffer Die Geschichtliche Entw, etc, p. 203.

[38]Chemistry, in its application to Agriculture and Physiology, edited by Lyon Playfair, Philadelphia. T. B. Peterson, Part Second, pp. 87, 119.

[39]Wundinfectionskrankheiten, Leipzig, 1878. Mith. d. kais- Ges. Amts Vol. I.

isolated twenty-eight species of this genus. Five of them are pathogenic to common mice.[40] Many of these Streptococci are not, however, pyogenic.

Ever since Ogston, Rosenbach and Passet demonstrated the presence of *Staphylococci* and *Streptococci* in pus, it has been universally held that they had some causal relation to the formation of pus. But, it is also a well established fact that pus may be formed without germs as was first demonstrated by Grawitz and later by Scheurlen and others. The aseptic introduction of turpentine, nitrate of silver, and sterilized pus cultures under the skin will give rise to pus. That certain other pathogenic bacilli and some saprophytic bacteria when sterilized can cause the formation of pus seems also to be reasonably well demonstrated. So universally are these pyogenic micro-organisms distributed that unless the greatest precautions are taken, they gain entrance to the wound and, the surgeon finds his patient not recovering as rapidly as he should. These pus organisms have a low thermal death point. The *Streptococcus pyogenes*[41], 52–57.4° C.

Staphylococcus pyogenes var. *aureus*[42] according to Sternberg is killed at 56° C., but Mr. Wade found in the writer's laboratory that it is somewhat higher, perhaps a different race[43]. This is a relatively low thermal death point since many species especially the anthrax bacillus produce resistent spores which stand 100° C. for several minutes. Some of the germs commonly found in the air like *Sarcina lutea* which do not form spores are only destroyed above 70° C. when heated for ten minutes.

There are few diseases which have awakened a deeper interest than tuberculosis in man and lower animals. The announcement of the discovery of the Bacillus was made by Koch[44] in 1882 and independently, about the same time, Baumgarten[45] discovered a specific Bacillus as the cause of tuberculosis. Villemin[46] as early as 1865 had shown that tuberculosis might be induced in healthy animals by innoculation of tuberculous material. These results were later confirmed by Cohnheim,[47] Salomonsen[48] and others. Baumgarten and Koch demonstrated the identity of tuberculosis in bovine animals and man. Later it was shown by Ernst and others[48] that milk from tuberculosis animals was infectious.

There was much hesitancy at first to accept the conclusions of Koch in regard to the infectious nature of tuberculosis, for the theory that tuberculosis was an

---

[40]Veranus A. Moore in a paper on Miscellaneous Investigations concerning Infectious and Parasitic Diseases of Domesticated animals. Bulletin No. 3, Bureau of Animal Industry, U. S. Dept. of Agriculture, pp. 9-30, gives an interesting account of the biology of some of these Strepteococci and also refers to the work of Smith, Salmon, Rosenbach and others.

[41]Sternberg's Manual of Bacteriology, p. 274.

[42]l. c. p. 267.

[43]It is possible that in this species as in *Bacillus pyocyaneus* there are different races as has been shown by several investigators.

[44]Die Aetiologie der Tuberculose, Berlin Klinische Wochenschrift, 1882, No. 5.

[45]See Baumgarten Lehrbuch der Pathologischen Mykologie Vorlesungen fur Aerzte und Studirende, Harold Bruhn, Braunschweig, pp. 973 with 100 figures. See page 535.

[46]Etude sur la tuberculose, Paris, 1868.

[47]Uebertragberkeit der Tuberculose, Berlin, 1877.

[48]How far may a cow be tuberculous before her milk becomes dangerous as an article of food, Hatch. Experiment Station Mass. Agricultural College Bulletin No. 8, April, 1890, Bang. Proc. Inter-nat. Medical Congress, Copenhagen, Vol. I., Path. Sect. p. II. 1884. McFadeyean and Woodhead, see Woodhead, Bacteria and their Products, p. 224.

Smith & Schroeder, Bull. No. 3, Bureau of Animal Industry, U. S. Dept. of Agriculture.

A contribution to the question of the danger of infection with tuberculosis through ordinary milk. The Journal of Comp. Path. and Therap., Vol. VI, p. 97.

inherited disease, was too strongly intrenched in the minds of physicians and people generally. But Koch brought such conclusive evidence in his first paper that the contagious nature of the disease could not be doubted and is now almost universally accepted. Physicians to-day use the methods proposed by Koch, Ziehl, Ehrlich and others for determining the presence of tubercle bacilli in sputum, lupus and other forms of the disease. A subject that was widely commented upon a few years ago in the press of the whole civilized world was the discovery of a toxic product, *tuberculin* in cultures of tubercle bacillus. This product discovered by Koch is soluble in glycerine. It is a powerful therapeutical agent. In very minute doses, when injected subcutaneously into tuberculous animals, it produces febrile and other decided symptoms. Dr. Sternberg[50] says: "This discovery must rank as one of the first importance in scientific medicine whatever the final verdict may be as to its therapeutic value in tubercular diseases in man." Numerous experiments have been made to determine its value as an agent in diagnosis of tuberculosis in bovine animals. These investigations have not only been carried on in Europe, but in our own country Dr. Pearson[54] has shown how valuable it is in cases of this kind. I may also refer to the value of another product, *mallein*, which Dr. Theobold Smith[55] and others have used with great success in diagnosis of glanders.

These and other results which have been obtained along the lines of bacteriology have been of inestimable value to the world at large. We cannot overlook the great work of Pasteur in affording immunity to persons bitten by mad dogs. Hydrophobia, that strange malady which has baffled medical skill will, it is to be hoped, be held in check by the work of this savant.

Although the cause of this strange and fatal disease is still a mystery, the benefits resulting from a series of innoculations are beyond dispute.

SUSCEPTIBILITY AND IMMUNITY.

We can now discuss briefly susceptibility and immunity. No question in general medicine and biology is more interesting than those which relate to susceptibility and immunity from disease in plants and animals. Certain animals and plants are much more subject to some diseases than others. Tuberculosis is common to man, bovine animals, apes and small herbivorous animals. Anthrax is most common in cattle and sheep; it may be communicated to man, guinea pigs, rabbits and mice. Rats, dogs, and birds are generally exempt. Glanders is most common in equine animals, occasionally forms a loathsome disease in man, but mice, rabbits and cattle are generally exempt. But this difference of a disease is not confined to different species; it often occurs in different individuals of the same species. Thus hog cholera of the U. S. Department of Agriculture[56] nearly always takes away a majority of the animals, but a few will not take the disease.

A case has come under my observation in which various pathogenic germs were innoculated into a rabbit, but all without avail. Again common laboratory experience shows that very young animals are much more liable to resist diseases than

Weitere Mittheilungen ueber das Tuberkulin, Deutsche Med. Wochenschrift, 1891, No. 43.

[50] Manual of Bacteriology, p. 387.

[54] Bull. No. 21, Pennsylvania Agrl. Experiment Station. E. P. Niles, Tuberculosis and the Koch test, Virginia Agrl. Exp. Station, vol. II, N. S. No. 3.

[55] W. B. Niles, Bull. No. 20, p. 729, Iowa Agrl. Exp. Station.

[56] Hog Cholera: Its history, nature and treatment, as determined by the inquiries and investigations of the Bureau of Animal Industry, pp. 199, with 16 plates. Government Printing office, Washington, D. C. See p. 34.

older animals. The same thing holds true in the human race, and very properly the term "children's diseases" is used for a number which are common to children and not older people. In older people some diseases are rapidly fatal, while other persons are exempt. The negro race is much more subject to tuberculous troubles than the white race. Small-pox is much more severe in dark races than fair skinned. The negro and latin races of tropical climates are more exempt from yellow fever than northern people. It is said on good authority that where cholera is indigenous, that the percentage of death is smaller than where it is not.[57]

Dr. Sternberg says:[58] "The tendency of continuous or repeated exposures to the same pathogenic agent will evidently be to establish a race tolerance; and there is reason to believe that such has been the effect in the case of some of the more common infectious diseases of man, which have been noticed to prevail with special severity when first introduced among a virgin population, as in the islands of the Pacific, etc."

In bacterial diseases of plants the same thing has been noticed; every horticulturist is familiar with the fact that some varieties of apples are more subject to the attacks of blight (*Bacillus amylovorus*) than others. It is certain that this susceptibility must depend on certain conditions in the animal body or plant, either favorable or unfavorable for the development of the pathogenic organism. It may be that the temperature fluids, of the body, or the blood serum as Buchner[59], Hankin[60] and others claim have valuable germicidal properties. The products of certain glands like the thymal are said to afford immunity. Fokker[60a] has recently published results which show that fresh milk has germicidal properties. It may be that the tissues of plants or structure of parts of cells, or the fluids of the plant are different from those attacked. Immunity from subsequent attacks varies in different diseases, and the time also varies. The theories advanced for immunity are the exhaustive theory, which holds that the organism growing in the animal exhausts the supply of some substance essential for its growth. But this has been set aside by Sternberg[61] and others.

The retention theory, proposed by Chauveau: This investigator holds that certain products formed during the development of the germ in the body accumulate and are retained. The vital resistance theory of Sternberg[62] explains immunity upon an acquired tolerance to the toxic products of pathogenic bacteria. There is much evidence to support this theory. The theory of phagocytosis, first prominently advocated by Metchnikoff, and sometimes called the Metchnikoff theory, is based on the fact that bacteria in the blood are picked up by the leucocytes. That immunity depends upon the power possessed by these leucocytes in destroying bacteria. There is no longer any doubt that the leucocytes pick up and destroy micro-organisms in animals, for since the germs found in these leucocytes are often corroded, and finally disappear entirely when health has been restored. Hankin[63] believes there is found in the body, as a result of disease, antitoxine, and these substances which are found in immune animals, he calls "defensive proteids;" these are clas-

---

57 Sims Woodhead, Bacteria and their Products, Chapters VIII and IX.

58 Manual of Bactierology, p. 227.

59 Centralblatt fur Bakt, und Parasitenkunde Vol. V, p. 817; Vol. VI, p. 1.

60 Proc. Royal Soc., London, 1890, May 22.

60a Fortschritt der Medicin Vol. VIII, p. 7.

61 Journal of Medical Sciences, April, 1881; Manual of Bacteriology, p. 238.

62 American Journal of Medical Sciences, April, 1881. Manual of Bacteriology, p. 240.

63 See Sternberg's Manual of Bacteriology, p. 260.

sified according to whether they occur in normal animals, *sozins;* second, those occurring in animals which have acquired an immunity, *phylaxins*. Sternberg,[64] than whom there is no higher authority in this country, says: "The experimental evidence detailed gives strong support te the view that acquired immunity depends upon the formation of antitoxine in the bodies of immune animals; as secondary factors, it is probable that tolerance to toxic products of pathogenic bacteria and phagocytosis have considerable importance, but it is evident that the principle role cannot be assigned to these agencies."

Sims Woodhead[65] thus summarizes immunity: "It appears probable that both the antagonistic action and this summative action are due to the bringing into play, or the depressing, of certain specific functions of the protoplasms of the cells by the products of different micro-organisms. It is not necessary that these functions should always be manifesting themselves; after being once evoked and exercised they may remain latent for a considerable period, and only be again called into action under the regular specific stimulus. It is a case of writing on the looking-glass with ink and with French chalk—the ink is always in evidence, and we might say that it corresponds to the enzyme, or the peptonizing functions exerted by certain cells, animal and vegetable, whilst the French chalk, though always there, is only brought out when the glass is breathed upon."

BACTERIA OF THE INTESTINAL TRACT.

In a previous paragraph I referred to studies made by Hallier and others on Asiatic cholera, and the pleomorphism of bacteria. This disease, which for centuries has carried away thousands of human lives every year, is certainly worthy of the deepest and most profound studies of physicians and bacteriologists. That the disease is contagious in its nature has long been recognized. The distinguished investigator, von Pettenkofer, long worked in vain for the specific cause. His work on the spread and distribution of the disease is a most important contribution to the literature of the subject, especially his researches on the relation of ground water and the "drying zone" to cholera epidemics. The splendid achievements of Robert Koch who was sent by the German government in 1883 to study cholera in Egypt and India made his name famous. On this mission he demonstrated a specific micro-organism which he called the "comma bacillus," but which belongs to the spiral forms and is known as *Spirillum choleræ asiaticæ*. This germ was found in the dejecta of patients suffering from this disease, in cesspools and water which received the dejecta, in milk, etc. It was not as easy to convince scientists and physicians that the germ found by Koch was the cause of Asiatic cholera, since Finkler and Pryor[66] found a germ in Cholera nostras which appeared to be identical, and Deneke[67] found apparently the same germ in old cheese.

Miller[68] found a comma bacillus in the human mouth; moreover, Klein, an eminent English authority, claimed that Koch's material was entirely harmless. Although the evidence of a specific germ is not so conclusive in this disease as in anthrax and tuberculosis, yet the accidental innoculation of a young physician in

---

[64] Manual of Bacteriology, p. 262.

[65] Bacteria and Their Products, p. 379.

[66] Untersuchungen uber cholera nostras. Deut. med. Wochenschr, 1884, No. 36, etc.

[67] Ueber eine neue den Choleraspirillen ahnliche Spaltpilzart. Deut. med. Wochenschr, No. 3, 1885.

[68] Kommaformiger Bacillus aus der Mundhole. Deut. Med. Woch, 1855, No. 5. Micro-organisms of the Human Mouth, Philadelphia, 1890.

Koch's laboratory in Berlin with this germ, who became sick and had the symptoms of genuine cholera, the experiments of Ferran, Koch, Gamaleia and others with guinea pigs, leave no doubt as to the causal connection of organism and Asiatic cholera. It is generally recognized now as the cause of this disease. There are many apparent anomalies as shown in the distribution of cholera and von Pettenkofer's "ground water theory," which are fully set forth in Dr. Shakespeare's[69] splendid monograph on cholera. If the contagious nature of the disease and the biological questions are taken into account, these conditions can be accounted for. The history and spread of this disease all show how important it is to take heed of sanitary conditions. It shows that the disease spreads most rapidly where effluvia and excreta contaminate the water; food, too, may be an important item. That old habit of using sewage water to sprinkle over vegetables, or the use of night soil for growing vegetables is an extremely dangerous thing.

WATER ANALYSIS.

This brings up the question of making bacteriological analysis of water and in this connection we may discuss typhoid fever. It is a well recognized fact that this disease is caused largely through the use of water and food that contains the active virus. The causal connection of the Koch Eberth bacillus and typhoid fever is generally conceded, but the proofs are not as certain as in some of the other contagious diseases, since bacteriologists have not been successful in producing typical typhoid fever in lower animals. This is not surprising since there are no animals that take this disease as man does. But it is pathogenic to mice and lower animals. A study of the typhoid fever bacillus is not an easy matter since there are several closely related species like *Bacillus coli-communis* which normally occur in the colon of man, other forms of this species occur in dysentery, cholera infantum, catarrhal enteritis, gastro-enteric catarrh, peritonitis and other diseases. Other germs of this general character are quite common in decaying substances, and some are pathogenic. The hog cholera germ, swine plague; the *Bacillus coli-communis* are well known for their pathogenic properties. Dr. Theobold Smith[69] has, however called attention to some important characters of the germs when grown in the fermentation tube, which enables us to separate *coli-communius* from nearly allied forms.

It has long been customary to regard a chemical analysis of water sufficient to determine whether water is good for drinking purposes or not. There seems however, to be a rapidly growing tendency to move along biological lines. I would not underrate chemical analysis, it should go hand in hand with this biological work. There are so many problems that the biologist cannot explain unless the chemist is at his elbow. Dr. Stevens says: "It is perhaps enough to say that a chemist is not of necessity a sanitarian, nor is his work the most important basis upon which a sound or safe conclusion is built as to the proper hygienic value of water for potable uses." Mr. Rafter[74] a well known sanitary engineer says: "Attention should be called moreover to the general proposition that the chemical methods are so refined in their nature that a slight error is liable to invalidate the results; whereas the microscopic analysis has the advantage of making the bulk of the organic contaminating material visible to the sense of sight." The chemist can determine that

---

[69]Report on cholera in Europe and India, pp. 945, with numerous charts and diagrams. Washington, Government Printing Office, 1890.

[69]Centralbatt fur Bakteriologie und Parasitenkunde, Vol. XII, p. 367.

[74]On the micro-organisms in Hemlock water. The quotation from Stevens is taken from this paper.

there is an organic impurity, the bacteriologist can tell what the impurity is. Bacteriologists have made many analyses of water and sewage. The methods used are still open for improvement. Water analysis is indeed a difficult problem.

Prof. Sedgwick,[75] in an exhaustive treatise on purification of water and sewage in report of the Massachusetts State Board of Health, says: "Although microscopical analyses (so-called) of water or sewage have often enough been undertaken the methods employed have hitherto been so imperfect that little importance has been attached either to the examinations themselves or to the results."

There are two ways in which water may be examined: First, microscopically; second, cultures. The former was the method chiefly in vogue before the use of the Koch system of cultivating germs. This method was employed by Cohn [76] and Radelkofer [77] in making examination in Breslau and Muenich. The bacterial examination of water requires cultures, and this is a very important part of the work. But I do not believe that culture examination is sufficient for this work. The Massachusetts State Board of Health employed Dr. Sedgwick, a well known authority in biological research, to make a biological study of sewage and drinking water. A new method was introduced as the combined work of Kean, Sedgwick and Rafter [78] which makes it a comparatively easy matter to determine approximately the microscopical organisms.

Jœrgensen[70] has well stated that the exclusive use of gelatine in this branch of biology may introduce sources of error. Hansen's work, as well as that of Jœrgensen, was more especially intended for zymotechnical purposes, and yet I believe it is equally applicable in hygiene. It may be well to start a series of cultures in small flasks that contain sterilized sewage or water, with some organic matter. For a study of these germs the Hansen method may be used. I believe that good results may be obtained by using liquid media. Miquel's[71] work certainly shows good results. The use of the fermentation tube, as suggested by Dr. Theobald Smith,[72] is a most excellent device. Many of the bacteria found in faeces are gas generators and by use of the fermentation tube which contains bouillion and sugar, the kind and quantity of gas produced may be determined readily. Stoller[73] has recently used this apparatus extensively with some success in arriving at the quantity of faecal bacteria in water.

The most important methods in bacteriological examination of water are those of the Koch school. In this method a known quantity of water, a fraction of a cubic centimeter is put in gelatin or agar and the number of germs which develop are counted. Obviously the smaller the fraction the more danger there will be of making errors in giving the result of the number of germs per cubic centimeter.

[75] A report of the Biological work of the Lawrence experiment station of Massachusetts State Board of Health, 1888-1890.

[76] Ueber den Brunnenfaden (*Chrenothrix polyspora*) mit Bemerkungen ueber die Mikroscopische Analyse des Brunnenwassers, Beitraege zur Biologie der Pflanzen I, p. 108 Breslau 1870.

[77] Mikroskopische Untersuchung der Organischen substanzen im Brunnenwasser, Zeitschrift fur Biologie I (1865), p. 26.

[78] Experimental investigations, Mass. State Board of Health, 1888, 1890, Pt. II, pp. 803, 811. Recent Progress in Biological Water Analysis, Journal of the New England Water Works Association, September 1889. The Biological Examination of Potable Water, Proceedings Rochester Academy of Sciences, 1890.

[70] L c, p 48.

[71] Annuaire del' Observatoire de Montsouris 1877-1890. Not seen in the original.

[72] Centrallblatt bur Bakteriologie und Parasitenkunde. Vol. VII, p. 302, and Vol XII, p. 367.

[73] Science, Vol. XXII, No. 564, p. 286.

Various bacteriological analyses made in Europe and the United States show that the bacterial contents differ greatly. Dr. Gruber[79] sets the maximum number of colonies to be found in spring water from 40 to 50, in well water 300 to 500 per c. c. Frænkel states that good drinking water should not have more than fifty germs per cubic centimeter. Many bacteriologists place the limit at 1,000 germs per c. c. It is stated that water taken from the Croton reservoir, New York, contained from 5,000 to 15,000 germs per c. c., and Messrs. McCall and Patton found in well water from a well near the Iowa Agricultural College, 320 germs per c. c. Spring college water supply only contained 56 germs per c. c. Water taken from the Muenich supply contained from 305 to 12,606 germs per c. c. Frænkel[80] estimated the number of germs in the water supply of Berlin at 6,140, while below the city there was a great increase, the number being 243,000 per c. c. The Kiel water supply, according to Breuning[80a], has from 62 to 1,712 germs per .5 c. c., the number of liquefying species varying from 4 to 188. Wells in the same city in some cases had more than 26,000.

Sewage, of course, contains an enormous number. Out of 126 analyses of Lawrence sewage, the number was 708,000 per c. c.; the minimum was 102,400; and maximum, 3,963,000. Fourteen analyses show more than 1,000,000 per c. c. It is not strange that sewage should contain such large numbers, since the putrefying material is especially favorable for their development. Nor is it strange that well water should often contain large numbers, since the upper strata of the soil teem with bacteria, and it is especially easy for water from the surface to find its way into the well. In bacteriological analysis of water it is not so important to determine the number as it is the quality of the germ. It is of special importance to take into account the pathogenic organisms, like the typhoid fever bacillus, and the spirillum of Asiatic cholera, in cases of epidemics of the latter disease. The liquefying species, such as peptonize gelatin, are more important than those which do not, since many of these give rise to very disagreeable odors, and perhaps poisonous products. What becomes of the germs found in sewage? It is certainly important to know whether they will continue to contaminate cities using the same water and lying farther down the stream.

Water may be purified in two ways: 1. Self-purification; 2. Purification by filtration. In this paper we are only concerned in the first. Destruction by various small animals, chemical action, sedimentation, and direct sunlight. The chemical action is perhaps due largely to oxidation; the mechanical effects of the small particles in the water must act to a considerable degree on the germs; the sediment carries with it much organic matter; this sediment, as experiments have shown, contain pathogenic germs. Perhaps the most powerful agent is sunlight. Buchner,[81] Marshall Ward, and others, have shown that exposure of typhoid bacillus, anthrax and other germs to direct sunlight destroys their pathogenic properties and inhibits their growth very materially. That there is a constant decrease in the number of germs at some distance below the point where sewage empties into the stream, numerous analyses have shown.

[79]Schrank. Anleitung zur Ausfuehrung bacteriologischer Untersuchungen zum Gebrauche fur Aerzte, Thieraerzte, Nahturungsmittel—, Agricultur und Gaehrungs-chemiker, Apotheker und Bautechniker, pp. 255, with 137 figures. Leipzig und Vienna. Franz Denhicke, 1894.

[80]l. c. p. 820.

[80a]Bacteriologische Untersuchung des Trinkwassers derStadt Kiel im August und September, 1887. Inaugural Diss., pp. 38. Kiel, A. F. Jensen.

[81] Bot. Centralblatt Vol. LII., pp. 61, 398.

DISEASES OF PLANTS AND INSECTS.

In this lengthy sketch on pathogenic germs the relations to hygiene have been touched on sufficiently. I have not discussed many of the diseases, but with such a vast subject, it is impossible to do so. Before I proceed to discuss the uses of bacteria to agriculture, let me briefly refer to a few of the diseases they cause in plants. Scarcely a decade ago DeBary,[82] Hartig[83] and other phytopathologists believed that the acid reaction of higher plants was detrimental to the growth of bacteria in living tissues. Since then it has been shown that many bacteria find acid media an excellent medium; moreover European, but more especially American investigations have shown that quite a number of plant diseases are caused by these minute organisms. The pioneer work in fact in this direction was paved by Americans. Most European authors like Kramer[84] and other bacteriologists scarcely enumerate the work done by Americans.

The only writers who have fully comprehended the subject are Ludwig of Greiz,[85] and Comes[86], of Italy, yet more than a decade ago Professor Burrill[87] worked out the causal relation between pear blight and *Bacillus amylovorus*. This was soon followed by the work of Prof. Arthur[88] on the same disease, and finally some excellent work by Waite. Then followed the investigation of Burrill[89] on sorghum blight, the work of Kellerman and Swingle[90] on the same disease. Tuberculosis of the olive by Savastano[91], blight in oats by Prof. Galloway[92] and Wakker's[93] Yellows of Hyacinths has become quite familiar to phytopathologists of Europe.

It has been demonstrated that there are other plant diseases caused by micro-organisms. These have been tabulated in an interesting paper by Dr. Russell[94].

Not the least value may be expected from the part that micro-organisms play in causing diseases of insects. Flacherie of the silkworm (*Streptococcus bombycis*) long ago studied by Bechamp[95] and Pebrine (*Nosema bombycis*) discovered by Cornalia and carefully studied by Pasteur and Naegeli are the oldest among the known diseases caused by bacteria. Both are most troublesome enemies of silk culture. Pasteur rendered this industry most important aids in suggesting the separation of the moths in pairs in isolated numbered cells, and a microscopical examination of the mates after they had deposited their eggs. The eggs from diseased insects are not to be used for breeding purposes. Whether this organism is to be classed with Bacteria or is one of the *Sporozoa* is still undetermined. Metchnikoff classifies it with *Sporozoa*.

Foul brood of bees, a most troublesome disease in the apiary, is caused by *Bacillus*

---

[82] Lectures on Bacteria, 1887.

[83] Lehrbuch der Baumkrankheiten.

[84] Die Bakteriologie in ihren Beziehungen zur Landwirtschaft und den Landw, Technischen Gewerben. Pt. I, pp. 171. Pt. II, pp. 178. Carl Gerold's Sohn Vienna. 1890-1892.

[85] Lehrbuch der niederen Kryptogamen, 1892.

[88] Annual Report New York State Agr. Experiment Station, 1884, p. 357.

[89] Eighth Ann. Meeting Soc. Prom. Agrl. Sci., p. 30.

[90] Annual Report Kansas Agr. Experiment Station, 1889.

[91] Ann. D. R. Scuola. Sup. d'Agri. in Portici, Vol. V, fasc. IV, 1887.

[92] Journal of Mycology, vol. VI. 1890.

[93] Bot. Centralblatt, Vol. XIV, 1883, p. 315.

[94] l. c. pp. 35-41.

[95] Bechamp.: Compt rend., Vol. LXIV.

Pasteur: Etudes sur les Maladies des vers a soie, Paris, 1870.

Balbiani, Lecons, sur les Sporozoairies, Paris, 1884.

alvei. The causal connection of this germ and "foul blood" was first established by Watson Cheyne.[96]

Many bacterial diseases of insects are beneficial, like "flacherie" of the cabbage butterfly (*Pieris rapae*) the bacterial disease of "chinch bugs" (*Streptococus insectoruu*) carries large numbers of this troublesome pest away. In this country Prof. Forbes[97] was the first to study "flacherie" and other bacterial diseases of insects. That these spread rapidly was shown by Prof. Osborn[98] who introduced diseased worms of the cabbage butterfly from Illinois. Later, C. V. Riley.[99] and under him F. W. Mally,[100] carried on some experiments with contagious germs to determine whether the "boll worm" could be held in check. Prof. Snow[101] of the University of Kansas, has also carried on a long series of experiments with the "chinch bug" disease. From the results obtained by these investigators there is no doubt that if the germs are carried over successfully either by the insects, or cultivated in nutrient media, that they may be utilized with advantage. Of course the insects must be gregarious, so that the disease can be spread easily. It is too soon to make any general predictions concerning the application of this work in holding insects in check, but we may confidently expect that it will find application in applied entomology.

We may note in this connection that Loeffler has successfully spread a disease of field mice, *Bacillus typhi-murinum*, in Southern Russia, and in this way materially checked this plague.

BACTERIA OF SOIL.

Let us briefly turn our attention now to a consideration of the bacteria of soil and the decomposition of organic matter, the formation of nitrates and nitrites. It has well been said that while bacteria cause much misery in the world they are great benefactors. Without them there would hardly be any rot nor decay. Our beautiful landscapes could not exist. The earth, garnished with the bloom of flowers, the green herb, its magnificent forests, our cereals and food plants, would not have the material from which to build up their fabric, except for these tiny plants. The nitrogen so essential for all living plants is only made ready for the use of most green plants by these wonderful micro-organisms.

Nitrification formerly meant the production of niter, a natural product of certain soils and rocks, but modern chemists have given to the word a wider meaning. It concerns the formation of nitrates and nitrites.

The older theories are discussed in various works on agricultural chemistry[102].

The first suggestion that nitrification was caused by a ferment was made by Mueller[103], but the true nature of nitrification was worked out by the French

96 Frank R. Cheslre and Watson Cheyne, Journal of the Royal Microscopical Soc. 1885, p. 11.

J. J. MacKenzie, The Foul Brood Bacillus, *B. alvei*; its vitality and development, 18th Annual Report Ontario Agricultural College and Exp. Farm, 1892, pp. 267-273.

97 Contagious diseases of insects, Ill. State Laboratory of Natural History. Bulletin

98 Iowa Horticultural Report, 1885, Insect Life, Vol. III, p. 143.

99 The Outlook for Applied Entomology, Insect Life, Vol. III., p. 197.

100 Report on Boll Worm of Cotton, Bull. No. 29, Division of Entomology U. S. Department of Agriculture, 1893.

101 Insect Life, Vol. III., p. 279.

102 Johnson, How crops grow, p. 391, New York, Orange Judd Co., 1888; Storer, Agriculture in its relation to chemistry, etc., etc.; Warrington, six lectures on the investigations at Rothansted Experimental Station, delivered under the provisions of the Lawes Agricultural Trust, before the Ass. Am. Agrl. College and Experiment Stations, Washington, Aug. 12-18, 1891; Experiment Station Bulletin No. 8, office of Experiment Stations U. S. Dept. of Agrl., Washington, Government Printing office.

103 Landw. Versuchs Stat. Vol. XVI, p. 233.

chemists, Schloesing and Muentz[104], who announced, in 1877, that they had established, by a series of experiments, that nitrates in the soil were formed by a micro-organism. They showed that 212 degrees Fahr. for one hour was sufficient to destroy the agent that caused nitrification. Further experiments made by these investigators show the importance of taking into consideration the temperature of the soil. In summer the temperature is more favorable for nitrification. The absence of strong light is a necessary condition for this same process. An alkaline condition of the medium is essential, but the amount, as Warrington says, is injurious if anything beyond a small proportion, and a large amount will prevent the action altogether.

The present theory of nitrification is that there are two stages, and each process is brought about by a distinct organism. At least this is true in the nitrification of ammonia, and the nitrification of nitrogenous matter falls under the same head. Warrington,[105] in an admirable paper, says: "By one organism the ammonia is converted into nitrites; by the other the nitrite is converted into nitrate. The existence of these two distinct agents, each of which has special conditions favorable or unfavorable to its development, explains at once the particular formation of nitrous or nitric acid, so frequently observed in laboratory experiments on nitrification." In the soil these two different organisms are abundant; the conditions for their growth being similar, they work together. The most interesting point in connection with these organisms is their growth in nutrient media. Isolation has been attended with much difficulty. The first attempt to grow them was made by Schloesing and Muentz; although they may have had the nitrifying agent, they worked with material that contained other germs. Koch's methods of growing bacteria in solid media, like agar and gelatin, wholly failed to accomplish the desired result. The first success in cultivating the nitrifying organism was made by D. P. F. Frankland.[106] His cultures were started in an ammonical solution, and by the dilution method he finally succeeded in obtaining a single species.

Warrington[107] by the same method succeeded in isolating the organism in the same way. Winogradsky[108] also succeeded in isolating and growing the germ. So much for the isolation of the nitrous organism. The separation of the nitric organism has been attended with equal difficulty, but Winogradsky[109] by an ingenious method has succeeded in growing the nitric organism on gelatinous silica. A most interesting feature of these organisms, the nitrous and nitric, is that they grow in inorganic fluids. Warrington[110] says: "That an organism unprovided with chlorophyll and growing in darkness, should be able to construct organic matter out of ammoniacal carbonate is certainly of the highest interest." Connected with the subject of nitrification is that of denitrification. Numerous investigators have called attention to the breaking up of nitrates in sewage. In some cases as in *Bacterium denitrificans*[111] the nitrate is changed into nitrogen gas. But these nitrogen gas species are evidently not common. The species which reduces the nitrates are numerous as shown by various recent investigations.

---

[104] Compt. Rend. Vol. LXXXIV, p. 301.
[105] l. c., p. 63.
[106] Phil. Trans. Roy. Soc., 1890, B., p. 107.
[107] Transactions Chem. Soc. 1891, p. 502.
[108] Ann. d l' Institut Pasteur, 1890, p. 213.
[109] Compt. Rend., Vol. CXIII, 1891, p. 89.
[110] J. M. N. Munro, Trans. Chem. Soc., 1886, p. 651.
Warrington l. c. p. 49.
Winogradsky, Ann. d l' Institut Pasteur, 1890, p. 268.
[111] Gayon and Dupetit, Ann. de la Science Agronomique I (1885), p. 226.

Warrington found 37; Jordan[112] has also found several in the sewage of Boston water supply. Prof. G. E. Patrick made an examination for the writer of eight species; of these five were energetic reducers of nitrates to nitrites. This property was not confined to facultative anaerobes. *Sarcina lutea, Streptococcus cinnabareus* are both aerobic, and yet are energetic reducers.

This field of bacteriology is a most fascinating and an important one. The whole subject of decomposition of organic matter might well engage the attention of many investigators. The results of Schlœsing and Muentz on nitrification and the erosion of rocks through the agents of bacteria, the brilliant achievements of Winogradsky, Warrington and others on these questions should be brought to the attention of agriculturists. These problems are important in the production of crops, and may well stimulate for a knowledge of things that seem hidden.

Let us now consider the appropriation of nitrogen in leguminous plants. Leguminous plants as renovators of our soils has been an established axiom in agriculture for years, but it is only within recent times that this was properly accounted for. Did not Boussingault show that plants cannot take up the free nitrogen of the air through the leaves of plants?

Scientists generally opposed Ville's idea that some plants have the power of taking up free nitrogen, but after nearly half a century of investigation, the world at large has come to accept his conclusions. The various phases of the appropriation of atmospheric nitrogen because of the nitrogen found in the tubercles, and the symbiotic relation to the plants in question, has received wide discussion in the agricultural and scientific papers. It is because the economic and scientific phases are so important and interesting from practical and chemico-physiological standpoints that they have been considered in this way. The practical farmer is interested in the accumulation of nitrogen in soil through the decay of tubercles and the appropriation of nitrogen by the plant. It makes his soil more productive. The chemist and biologist are interested in finding out facts in regard to how this is accomplished, the structure, form and relationship of the organisms in question.

I presume most of you are familiar with the earlier work. At one time they were supposed to be insect galls. Bivona[113] thought they were fungi and placed them in the genus *Selerotium*. Tulasne, with his great knowledge of fungi, cast them out of this group of plants. Later they were held to be normal structures of the plants, "swollen lateral roots," "imperfect buds," normal structures of the roots for the storage of reserve food material. Prof. Atkinson,[114] who has made a most excellent summary of the investigations, reviews the status of the question in three periods, early, middle and recent. During the middle period the preponderance of evidence seems to have been to regard them as normal structures for the storage of reserve food material, although the views of some authors were diametrically opposed. Frank, who at first supposed them to be fungi, related to the genus *Protomyces*, established by De Bary, later entirely abandoned this view and thought they were simply for the storage of proteid material. In this he was supported by Brunchorst, Tschirch and Van Tieghem. Woronin, Kny and others held that they were living structures related to *Plasmodium brassicæ*. Later

112 l. c.

113 Quoted by Atkinson. Contribution to the Biology of the organism causing leguminous tubercles, Bot. Gazette. Vol. XVIII, pp. 158, 226, 257, where there is a most excellent bibliography. There is also a good review by Conn. Experiment Station Record, Vol. II, pp. 686-693.

114 l. c.

researches made by Ward[115], Hellriegel and Wilfarth[116], Laws and Gilbert[117], Beyerinck[118], Prazmowski[119], Laurent[120], Frank[121], Atkinson, and a host of others, leaves no doubt as to the organisms found in the tubercles.

The results of these later investigations show that in sterilized soil, leguminous plants make but little growth and the tubercles will not develop. The results have been further supplemented by the successful culture of the organisms by Frank, Prazmowski, Laurent, Atkinson and others. There is much conflicting testimony as to the true nature of the changes produced and the structure of the organism. Atkinson says: "The important question is, can these various conflicting notions of the biology of the microsymbiont be harmonized? Leaving out of consideration for the present the real nature of the organism it will be admitted by those who take the trouble to familiarize themselves with the scope of the work covered by the most important investigations that the organism in question consists of an elongated thread-like structure, which branches freely within the tubercle and possesses enlarged portions which present a more or less finely lobed surface; and very much smaller forms which must exist to some extent within the tubercle, are capable of multiplying in artificial media, and when transplanted from artificial media to the roots of leguminous plants, are capable under these more natural conditions and the stimulus of the microsymbiont, of growing out again into the threadlike structures."

As to the place of the organism in the system of plants there is much diversity of opinion. Laurent, as well as Ward, concluded that they were not bacteria but low fungi. Atkinson says: "While in some characters, as noted above, the tubercle organism is very much like *Cladochytrium tenue*, yet in the sum of essential characters it departs too widely from that genus, so that even if it should eventually be clearly shown to be one of the *Chytridiaceæ*, it would still be referable to *Phytomyxa*."

Frank, Prazmowski, and others placed it with bacteria.

Whatever the final disposition will be, Atkinson, it seems to me, has good grounds for calling it *Phytomyxa*.

It is not my purpose to discuss at length the chemical problem, but it may be well to give the opinions of the more recent investigations. J. H. Gilbert[122] says: "The facts at command did not favor the idea that the plant was enabled to fix this free nitrogen by its leaves. It seemed more consistent, both with experimental results and with general ideas, to suppose that the nodule bacteria fixed free nitrogen within the plant, and that the higher plant absorbed the nitrogenous compounds produced." Atwater and Woods[123], while they show that there is an acqui-

115 On the tubercular swellings on the roots of Vicia Faba. Phil. Trans. Royal Society, CLXXVIII (1887). pp. 139.

116 Untersuchungen ueber die Stickstoffnahrung der Gramineen und Leguminosen. Beilageheft z. d. Zeitschr. f. d. Rubenzucker Ind. d. D. R. Berlin, Nov., 1888. Review in Bot., Central b. XXXIX. (1889). 138.

117 On the present question of the sources of the nitrogen of vegetation, etc. Phil. Trans. Royal Society, CLXXX. B. 1-107.

118 Die Papilionaceenknoellchen, Bot. Zeit. 1888, p. 725-735, 741-750, 757-771, 780-790, 797-804.

119 Das Wesen und die biologische Bedeutung der Wurzelknœllchen der Erbse. Bot. Central b. XXXIX. (1889). 356-362.

120 Ann. d. l'Institut Pasteur. V. (1891). 105-139.

121 Ueber die Pilzsymbiose der Leguminoseen. Berlin, 1890.

122 Experiment Station Record, Vol. III, p. 333.

123 Atmospheric nitrogen as plant food. Bull. No. 5, Storr's School Agrl. Exp. Station, Conn., Oct., 1889.

sition of nitrogen in leguminous plants above that found in the soil, are certain of the symbiotic relation of the plant and organism. They leave the question how it is done an unsolved problem. Nobbe, Schmid, Hiltner and Hotter[124] are of the opinion that the nitrogen which the plant contains comes from metabolic processes.

Whatever the future may decide, it is certain that the tubercles are widely distributed on exotic and indigenous, leguminous plants[125].

The ground seems to be gaining that certain low forms of plants[126], including bacteria, have the power of greatly enriching the soil in nitrogen, and we may add that Frank believes that many higher plants can appropriate free nitrogen without tubercles. Frank's general conclusions are not generally accepted by botanists and agricultural chemists.

We have another most interesting case of symbiosis among bacteria. Professor H. Marshall Ward[127] who studied the fermentation of ginger beer finds that a number of micro-organisms are concerned in this fermentation. Ginger beer as most of you know is made by adding to saccharine solutions a quantity of ginger, and a ferment, the latter changes to an effervescing beverage. This alcoholic and viscous fermentation contain moulds, yeast-fungi and a constant bacterium. The yeast-fungus concerned in this fermentation is *Saccharmgees pyriformis*, the Schizomycete is *Bacterium vermiforme*. This according to Prof. Ward originates from the ginger. The vermiform bacterium is enclosed in hyaline, swollen gelatinous sheaths. This organism imprisons the yeast. The anaerobic bacterium only produces the gelatinous sheaths in saccharine liquid in the absence of oxygen. Now Ward has shown experimentally that only when these two species occur together can the ginger beer be produced.

BACTERIA IN THE DAIRY.

One of the greatest achievements in modern science is the application of scientific principles and utilize them in the arts and industries. Since time immemorial yeast has been used for the manufacture of beer[128], known to the ancients as barley or Pelusian wine. Its manufacture evidently spread from Egypt over Europe. Much advancement has been made. Beginning with Pasteur's Studies on Fermentations, the subject was treated from a rational and scientific standpoint, culminating in the brilliant researches of Emil Christian Hansen and Joergensen of the Copenhagen school. The nomadic tribes of Tartary since time immemorial have prepared a fermented drink from mares' milk known as koumiss. The kefir, another fermented drink of milk has long been made by the inhabitants of the Caucasus. Scientists were made familiar with this drink as early as 1784, but it devolved upon modern scientific investigation to rationally explain the causes of this fermentation. There are other ways in which a study of bacteriology is rendering important aid to our modern industries. We need not go far back in the history of bacteriology when it was supposed that the souring of milk was a purely chemical process. Sheele had discovered lactic acid in whey in 1780. Pelouze and Guy Lussac

124 Landw. Vers. Stat., Vol. XXIX, pp. 327-354.

125 H. L. Bolley, Agricultural Science, Vol. VII, p. 58; records them on twenty-eight indigenous and sixteen exotic plants in North Dakota.

126 Berthelot. Compt. rend., Vol. CXVI, pp. 841-849. Experiment Station Record Vol. IV, p. 854.

127 The ginger beer plant and the organisms composing it. Phil. Trans. Roy. Soc Vol. CLXXXIII. p. 125.

128 Pasteur, Studies on Fermentation. The Diseases of Beer, their causes, and the means of preventing them. English translation, Faulkner and Robt. Landon. Macmillan & Co , 1879, p. 418, with 85 figures and 12 plates, see pages 1 and 17.

solated lactic acid in milk in 1833; Turpin in 1837, supposed that the cause of souring milk came from the mammary gland and was contained in the fat globules. Schwann and Latour, 1837, had laid the foundations to rationally explain the process of fermentation, making it certain that organized living beings caused the changes observed in a fermenting substance. Fuchs[129] was the first in modern times to examine milk microscopically. He found two germs; one he termed monas and the other infusor. Blandeau, 1847, incorrectly ascribed lactic acid fermentation to yeast (*Torula*) and the common blue mould (*Penicillium*). Liebig supposed that fermentation was a property of all albuminoids and this view gained credence in many quarters. But we must pass over these stumbling blocks in the history of this work and give in rapid succession the vital points which have made it possible to put the fermentations of milk on a high road to a successful use in practice. Pasteur, in 1837, thought souring of milk was due to an organized *Ferment lactique;* he also recognized that other organisms were present; to distinguish the two, he called it *Leveure lactique* caused by his *Vibrio butyricus*[130]. This germ was capable of standing a much higher temperature than the lactic acid organisms. In 1874 Lister, by using bacteriological methods, separated his *Bacillus lactis*, which we have seen led him to erroneous ideas.

Hueppe[131] somewhat later, 1884, made a thorough study of souring milk and referred Lister's *Bacillus lactis* to one which he described as *Bacillus acidi lactici*. In a second paper he concluded that souring was not caused alone by this species, but several. Marpmann,[132] Conn,[133] Storch,[134] Weigmann[135] and others have all shown that species of lactic acid germs are numerous. The power of changing milk sugar to lactic acid is not confined to Saprophytic species, but some of the pathogenic, like the Micrococcus of osteo-myelitis[136] has the power coagulating the casein of milk. Some of the chromogenes are very active in this direction. The *Bacillus prodigiosus* which often causes red milk in Europe, has this power. It is the famous blood-portent, connected with several superstitions, and certain lesions of the teats, which were supposed to cause bloody milk, is due to nothing more than the development of this bacterium, which may form lactic acid. Schottelius and Wood[137] have pointed out the interesting fact that as the temperature rises the power of forming pigment is lost "and, if it is grown on potato or bread paste, for example, in an incubator at blood heat instead of at the temperature of the room, the color is gradually lost and the culture no longer smells of herring brine, but the power of forming lactic acid from milk sugar, with the accompanying precipitation of casein, is frequently increased, so that it would appear that the energy required for building up pigment was, in this case, directed

[129] Mag. f. d. Ges. Thierheilkunde, 1841.

[130] Hoffmann, 1869, also described two species, a motile and a non-motile; the latter he thought caused the souring of milk.

[131] Untersuchungen uber die Zersetzungen der Milch durch Mikro-organismen mitth, aus dem K, Gesundheitsamte, Vol. II., 1884, Deutsche Med, Wochenscrh, 1884, No. 48.

[132] Ueber die Erreger der Milchsaeure Gaehrung Ergaenzungshefte, Z., Centrallblatt f Allg, Gesundheitspflege, Vol. II., p. 117.

[133] Storrs' School, Conn, Agr. Exp. Station, 1889, p. 82; 1890, p. 136; 1891, p. 192.

[134] Nogle Undersogelser over Flodens Syrning, etc.

[135] Die Bakteriologie im Dieuste der Milchwirtschaft Milch Zeitung, 1891, Nos. 19 and 20.

[136] Krause, see Alfred Jorgensen Micro-organisms and Fermentation, English translation, p. 63.

[137] Biologische Untersuchungen ueber den Mikrokkus prodigiosus, Leipzig, 1887, p 185. See Sims Woolhead Bacteria, etc., p. 11.

into another channel, and lactic acid and, perhaps, other substances are produced in place of the usual pigment."

Investigation has shown that the flora of milk is a variable one, owing to circumstances under which they make their entrance.

The normal milk from a healthy cow contains no germs. This is easily determined by using a sterilized catheter. The pails and water used to clean milking vessels and cans, the stable, hair from cows, and hands of milker, all have germs that find their way into the milk. The species found are not only abundant, as shown by various bacteriological studies of milk, but both good and bad occur.

Cnopf and Escherich,[137] found from 60,000 to 100,000 per c. c., in milk a few hours after milking. Mr. B. F. White, in the writer's laboratory, found that when milk was obtained in the ordinary way, and cultures made soon thereafter, it contained 40,000 germs per c. c. Milk coming to the creamery had, in some cases, as high as 1,976,000 per c. c. Prof. Conn[138] interestingly shows the enormous number in milk, as well as the great increase. The writer[139] has also brought together the results obtained by Miquel, Weigmann, and others, on the enormous increase, when milk is kept under favorable conditions for their development. That our milk supply of cities contains an enormous number has been shown by Sedgwick and Batchelder.[140] It is not to be wondered at that milk will sour in the course of a few hours on a hot day in summer.

The fact that different samples of milk left standing in a warm room will develop quite different odors is due to particular germs. The practical dairyman is well aware that he cannot always make butter of uniform quality, and this is owing to injurious species. Experiments made during the last few years have shown that by Pasteurizing milk and using the germs that have the right odor, butter of uniform and high quality may be produced. These results were first brought to notice by Storch, of Copenhagen. Weigmann, of Kiel, has also experimented with these germs in a practical way, sending them out to creameries. Prof. Conn, of Middletown, Conn., writes me that he has had success in using one of his own germs.

No one questions the fact that odors and products of bacteria are very characteristic. Storch has called attention to butter that had a flavor of beets, but the animal from which the milk came had never been fed on beets. Dr. Jansen[141] refers to a bacillus which was found in milk that produced a very fetid odor, his *Bacillus fœtidus.*

The writer has isolated a Bacillus which he has called *Bacillus aromaticus*,[142] because of the powerful volatile odor produced. In some media it has an odor characteristic of walnuts. Again it resembles limburger cheese, and a more interesting fact is that it tastes like cheese.

The importance of bacteria in ripening cream is very important, since cheese will not ripen unless Bacteria are present. Duclaux,[143] Adametz,[144] Freudenreich,[145] and

137 Abst. Centralb. Agrl. Chm., 1890, p. 575.

138 The Fermentations of Milk, Office of Experiment Stations. Bull. No. 9, U. S. Dept. of Agrl pp. 75, see p. 30.

139 The Bacteria of Milk, Cream and Cheese. Report Fifteenth Annual Convention of the Iowa Dairy Association, held at Waverly, 1891, p. 81.

140 A Bacteriological Examination of the Boston Milk Supply. Boston Med. and Surgical Journal, 1892, p. 25.

141 Centralblatt Bakt u Parasitenkunde, Vol. XI p. 409.

142 Bull. No. 21, Iowa Agrl. Experiment Station, pp. 792-796.

143 Le Lait etudes chimiques et microbiologiques, Paris, 1887.

144 Bakteriologische Unteruschungen ueber den Reifungsprocess der Kæse Landw Jahrbucher, Vol. XVIII. p. 228.

145 *Landw, Jahrbuch* der Schweiz, Vol. V, p. 16, Vol. IV, p. 17.

others have studied the flora of cheese. All find an abundance of bacteria present. They are ærobic and anærobic. Bacteria are very important to the cheesemaker. Cheese without bacteria cannot be made. First of all, in most cases it is necessary for the milk to sour so that the whey can be removed. Again it must pass through a stage of ripening before it becomes digestible. The species differ for different kinds of cheese, and there are several kinds connected with every cheese. As in milk, cheese has its enemies in bacteria. Some that cause abnormal ripening, or color it black, yellow or red.[144] Bacteria always play an important part in the formation of Koumiss. Kefir and other alcoholic fermentations come from Asia and Europe. Mix has shown that forms of alcoholic fermentation of milk occur in North America. The so-called Kephir grains contain the organisms essential for fermented drink Kephir. Yeasts and bacteria have been found. Kern[144] considers that *Diospora caucasica* causes the fermentation. Recent investigations leave much doubt in regard to its being an organism at all. Little is known concerning Koumiss, but that it is caused by some living ferment cannot be doubted. The nomadic tribes of Tartary prepared it from mares' milk, which readily undergoes alcoholic fermentation, Ordinarily it is prepared by adding a little Koumiss or sour, to the sweet milk.

Another interesting group of organisms found in milk are the slime forming bacteria. These organisms cause milk to become very viscous and 'ropy.' It can be drawn out in long threads. This slime, a product from the cell-wall, is analagous to the zoogloea formation in certain bacteria, and comes from the decomposition of sugar. Some of the species that can cause this are *Bacillus mesentericus, B. viscosus, and Micrococcus discosus,* Bechamp the so-called Frogspawn (*Leuconostoc mesenterioides*) found in molasses, etc. The species are not uncommon.

Lastly I should mention that bacteria are indispensable to housewives in the making of bread. In this case they are aided very materially by yeasts. Miss Golden[149] has made a contribution to our knowledge of this process and the role bacteria play in bread-making. Miss Golden concludes that bacteria as well as yeast separately can cause bread to rise but that both usually act together. Laurent[148] believes that his *Bacillius panificans* causes the rising of bread besides forming lactic, acetic, and butyric acids.

In conclusion, you will pardon me for having consumed so much of your time. In fact as I look over this question I cannot but think that the subject is so vast that one address will scarcely touch upon the many important problems. The subject of ptomaines and various products of bacteria, disinfection and other points have not been touched up, except incidentally. I venture to say that any one of the topics taken up in this address might very appropriately have consumed the entire time. I shall, however, feel repaid in preparation of this paper if some of the popular notions concerning these baneful and useful organisms, stand corrected.

---

[144]Adametz ueber die ursachen und erreger der abnormalen Reifungsvorgange beim Kæse pp. 70, with 6 illustrations. Bremen, 1893, M. Heinsius nachfolger.

[145]Contributions from the Cryptogamic Laboratory, Harvard University.

[146]Ueber ein Milchferment, Bot. Zietung, 1882, p. 264.

[149]Bot. Gazette, Vol. XV, p. 204.

[148]See Centralblatt f. Bakt. und Parasitenkunde, 1887, p. 504.

POWDERY MILDEW OF THE APPLE.

BY L. H. PAMMEL.

(Abstract.)

The past season was very favorable for the development of the Powdery Mildews. During the month of September Mr. G. W. Carver, a special student in the botanical laboratory, brought in a fine lot of The Apple Powdery Mildew. An *Erysiphe* and the common Powdery Mildew of the cherry, *Podosphaora oxyacanthæ*, have been reported on *Pyrus malus*.* But our fungus does not belong to either of these genera. It agrees with the descriptions given for *Sphærotheca mali* (Duby) Burrill. It is easily recognized by its persistent perithecia, two kinds of appendages. The long appendages come from the upper end; they are straight or curved, rigid, usually septate, and occasionally forked at the end The base is deeply colored. The rudimentary appendages are floccose and attached to the smaller end of the pyriform perithecium. Prof. Burrill records this species abundant at times in the Mississippi valley, and first referred it correctly to Duby's *Erysiphe mali*. Bot Gall, p. 869.

FURTHER NOTES ON CLADOSPORIUM CARPOPHILUM—VON THUEMEN.

L. H. PAMMEL.

(Abstract.)

This fungus was first recorded on the native plum *(Prunus americana)*, in a short note presented to the Academy some years ago.

I thought at first that the fungus on the plum and cherry might prove to be a new species, but I cannot see how the fungus differs materially from that found on the peach.

This fungus has become a source of considerable annoyance to the cultivation of the *americana* plums, in many sections of the United States and Canada. Most of the commonly cultivated forms of this specie are affected in Iowa. The DeSoto, Rollingstone and Speer, being attacked with special severity.

The Wolf plum, which is a variety of *Prunus americana*, is but little subject to the attacks of this fungus. *Prunus angustifolia* and *Prunus domestica* are not affected. Some varieties of *Prunus cerasus* are also affected.

*Ellis and Everhart: North American Pyrenomycetes, p. 6.

An interesting feature connected with the attacks of this fungus and different parts is that a hybrid of *Prunus americana* (DeSoto) and Oregon Plum, (*Prunus domestica* or possibly a Japan Plum) show the disease in a very marked form. This is interesting as indicating that the mother plant was strongly prepotent in carrying over a tendency to take a disease.

The fungus, or what appears to be the same thing, has been cultivated in nutrient agar, but innoculation experiments tried on matured plums did not show the characteristic appearance. The fungus grown in agar is either different or it attacks plums before the epidermal cells are uncuticularized. Field observations indicate that plums become affected early and that these spots increase in size as the season advances.

NOTES FROM THE BOTANICAL LABORATORY OF IOWA AGRICULTURAL COLLEGE.

BY L. H. PAMMEL.

It is a good plan to make a permanent record of some of the work done by undergraduate students, provided the observations are carefully made and recorded. During the winter of 1892 and 1893 there was a serious epidemic of typhoid fever in La Crosse, Wisconsin, which came to my notice through my brother, H. A. Pammel. I was asked to make a bacteriological examination of the water and report. It was impossible for me to do so because of other work on hand at that time. Two senior students, Messrs. McCall and Patton, then at work in the bacteriological laboratory, consented to work it up for their thesis. My brother collected the samples on May 2. They were placed in thoroughly scalded bottles and sent to me by express. Most of the samples of water were submitted to an analysis on May 10.

It is an extremely difficult matter to get satisfactory results made in this way. Some of the successful results in obtaining the typhoid fever bacillus of polluted water have been reported by Mr. Rafter and Dr. H. C. Ernst[1] in this country, and my friend, Dr. Ravold has reported some from Mississippi water taken at St. Louis. The number of successful cultures of this organism from polluted water is, however, somewhat limited, and in some cases, at least, there are doubts as to whether the investigators had the Koch Eberth bacillus or some closely related species. Cassedebat[2], who made an extended study of the river water at Marseilles, found several species closely related to it, but the true typhoid fever bacillus could not be found. This uncertainty is also indicated by the results of Babe's work[3].

The tabulated results of the work of Messrs. McCall and Patton show the number of colonies present to be as follows:

---

[1]Report on an epidemic of typhoid fever at the village of Springwater, N. Y., in October and November, 1889.

[2]Zur un bacille pseudo typhique trouve dans les eaux de riviere Compt. rend. Acad. des Sci. Vol. CX, 1889. Le bacille d' Eberth-Gaffky et les bacillis pseudo-typhiques dans les eaux de riviere, Ann. d l'Institut Pasteur, 1890, p. 625.

[3]Ueber variabilitat und varietaten des typhus-bacillus, Zeitschrift fur Hygiene, Vol. IX, 1890, p. 823.

Upon an outbreak of typhoid fever in Iron Mountain, Michigan, see Vaughan and Novy: The Medical News, 1888, p. 92. On the detection of typhoid fever bacillus see Foote: Medical Record, New York, 1891, p. 506.

DATE OF EXAMINATION.	NUMBER OF SAMPLE AND SOURCE.	Number of colonies per c. c.	LIQUEFACTION OF GELATINE.	KIND OF ORGANISM MOST ABUNDANT.	COLOR.	Pathogenic.	Typhoid fever bacilli.
No. 1. May 10.	Hydrant on Fourth street.	4,000	None.	Bacillus 4.5x1.2u. odorless, without formation of gas. Facult., anaerobes.	Yellow.	Not.	None.
No. 1. August 16. Water kept on ice.	do.	2,750				Not.	None.
No. 2. May 10.	Well No. 1128, Third and State streets.	5,725	Both kinds. No. 1 liquefying, No. 2 not.	Bacillus No. 1 2.25 u. in length; No. 2, 2.3u.x 1.5u.	White.	Not.	None.
No. 2. August 16.	do.	3,600				Not.	None.
No. 3. May 10.	Mississippi river.	3,000	Both kinds. No. 1 liquefying.	Bacillus, 1.5x.5; strong odor. No. 2, 4x2.3.	White.	Not.	None.
No. 3. August 17.	do.	1,240				Not.	None.
No. 4. May 10.	State and Eleventh streets. Well 100 feet deep.	7,804	Liquefying.	Baccillus No. 1, 1.5x.4u. No. 2, 1x3u.	Yellowish white and white; medium greenish.	Not.	None.
No. 4. August 17.	do.	4,000				Not.	None.
No. 5. June 2.	Well on Fourth street, Dr. Tillman's residence.	1,345	Both. No. 1 liquefying; No. 2 non-liquefying.	Bacillus, 1.5x6u.; No. 2, 2x.4u.	White. No. 1 greenish tinge.	Not.	None.
No. 5. August 21.	do.	1,250				Not.	None.

No. 6. May 10.	Artesian well supply.	6,804	Bacillus, liquefying. Micrococcus, non-liquefying.	Bacillus No. 1, 5x.4u. Micrococcus, .3u.	White. B., medium greenish tinge. M., white.	Not.	None.	Bacillus had odor of stale eggs.
No. 6. August 21.	do.	3,560				Not.	None.	
No. 7. September 1.	Creamery supply. I. A. C. hydrant.	320				Not.		
No. 7. September 13.	Farm house.	56				Not.		

Some experiments were also made in filtering germs out with the following results:

Water from veterinary hospital filtered through two, three and five thicknesses of filter paper, funnel, flasks and filter paper previously sterilized:

	Unfiltered.	Filtered.
Two filter papers	250 germs per c. c.	129 germs per c. c.
Three filter papers	250 germs per c. c.	24 germs per c. c.
Five filter papers	250 germs per c. c.	4 germs per c. c.

College water supply from main building filtered through a Pasteur-Chamberland filter after sterilization:

Unfiltered.	Filtered.
Fifty germs per c. c.	Sample No. 1, 4 germs per c. c.
	Sample No. 2, none.

Water supply of North Hall standing in tank partially open, filtered through sterilized asbestos:

Unfiltered.	Filtered.
Six hundred and fifty germs per c. c.	4 germs per c. c.

October 11th. Water taken from farm barn and filtered through sterilized glass wool.

Unfiltered.	Filtered.
Four hundred and eighty germs per c. c.	Sample No. 1, 120 germs per c. c.
	Sample No. 2, 100 germs per c. c.

These results show that so far as studying the Bacillus of Typhoid Fever, samples should be collected on the spot; examinations and cultures should be made immediately. A good many species were obtained, but none of these could be identified with the *Bacillus typhi-abdominalis*. Nor were any pathogenic germs present. Water kept in a cool place showed that in the course of several months, there was considerable diminution in the number of germs, but the number was still large for potable purposes. Water can be advantageously filtered by the Pasteur-Chamberland filter, ordinary glass wool; asbestos, and filter papers also remove many of the germs.

BACTERIOLOGICAL STUDY OF MILK AND ITS RELATION TO PUBLIC HYGIENE.

We present here also a very brief report of the work done by Mr. B. F. White on the above topic. By ordinary methods it is an extremely difficult matter to get milk from cows without germs. This, however, was accomplished quite easily by using sterilized milking tubes. The number of germs was determined by taking .25 c. c. of milk and pouring it in a known quantity of agar, making three dilutions. Each tube was poured out on sterilized glass plates and allowed to stand from 48 to 72 hours. They were then counted and some of the species cultivated in the usual media.

The following table shows the results of the work:

Number of sample.	Date of collection.		Number of germs per. c. c.	REMARKS.
1	August	27	540,000	Fresh milk in sterilized flask, without precautions, from College farm.
2	September	15	1,976,000	Skim milk from veterinary barn, brought from I. A. C. creamery.
3	September	26	2,246,400	Buttermilk, I. A. C. creamery.
4	September	27	1,701,000	Morning and evening milk brought to I. A. C. creamery. Six hours on road.
5	September	28	1,200,000	Milk from I. A. C. creamery.
6	October	2	3,510,000	College kitchen milk kept in room over night.

Many of the species were cultivated and tests were made with several species and different disinfectants. Corrosive sublimate, 1-1,000; pyoktanin, 1-1,000. They were left in the solution for 30 seconds, 5 minutes and 10 minutes. The material was taken up on the end of a platinum loop and placed in the disinfectant solution with the following results:

A COMMON BACILLUS.

	THIRTY SECONDS.	FIVE MINUTES.	TEN MINUTES.
CORROSIVE SUBLIMATE.	Rapid growth.	Slow.	Very slow.
PYOKTANIN.	Rapid growth.	Quite rapidly.	Very slow.

It was evident from the work that the material in direct contact with the disinfectant was destroyed, but that in the interior of the mass was less readily acted on, and grew, after a longer time, the disinfectant having not destroyed, but merely inhibited the growth of the germ.

Another experiment was tried in this case. The germs were thoroughly distributed in the solution and allowed to remain for a given length of time. A platinum loop full of the material was added to a known quantity of agar, and poured. The plates were allowed to stand twenty-four hours, with the following results:

CORROSIVE SUBLIMATE.

1-1000	Ten minutes.	No growth.
1-2000	Ten minutes.	No growth.
1-3000	Ten minutes.	No growth.
1-4000	Ten minutes.	No growth.

PYOKTANIN.

1-1000	Ten minutes.	No growth.
1-2000	Ten minutes.	No growth.
1-3000	Ten minutes.	No growth.
1-4000	Ten minutes.	Not all destroyed.

NOTES ON THE POLLINATION OF SOME LILIACEÆ AND A FEW OTHER PLANTS.

BY MARY C. ROLFS.

It will not be necessary in this connection to refer to the literature. This may be obtained from such works as Herman Mueller and Darcy W. Thompson. In the identification of insects help was obtained from Prof. Osborn and Miss Beach.

Erythonium albidum, Nuttall. This is the earliest of the *Liliaceæ* to come in flower, in fact one of the earliest of our spring flowers. Owing to numerous rains last spring it was difficult to study the species, and insect visitors were few. Flowers perfect. Nectar is secreted near the base of the inner divisions of the perianth. Two small beetles were found feeding near base of the perianth. Ants were found as incidental visitors often walking over stamens and pistil.

Visitors—HEMIPTERA—*Capsidae*, *Lygeus pratensis*, was also found in the flower. Mr. Charles Robertson reports twenty-two for Carlinville, Illinois.

Smilacina stellata, Desf. Found growing in low moist places. Flower perfect. Visited during early part of the day by flies feeding upon the pollen. The flowers opening in the early part of the spring, and are visited at first by *Diptera* almost entirely, but later its visitors were increased. The pistil has a three cleft stigma, ripens simultaneously with the stamens. They are of the same length. Insects in seeking the nectar, which is secreted at the base of the corolla, leave some of the pollen from another flower on the stigma.

Visitors— DIPTERA— *Muscidae: Musca domestica, Scatophago squalida, Tachina flavicaudla. Syrphidae:* Syrphus fly. *Bibionidae: Bibio albipennis Lyretta pipens* and *Mesograpta marginata* (feeding on the pollen), HYMENOPTERA *Apidae: Halictus albipennis, Halictus tegularia, H. zephyras. Nomada bisignata. Augochlora pura* and *Agapostemon radiatus* feeding on the nectar.

Polygonatum biflorum, Ell. Grows on shaded hillsides in large patches, perennial herb with simple curving stem, from creeping root stock. Flowers axillary greenish and nodding. Perianth cylindrical oblong, six lobed at summit. The six stamens are inserted on or near the middle of the segments of perianth, with introrse anthers. Style slender, obtuse, slightly three lobed stigma. Flower perfect. The perianth is about half an inch in length and the summit, or top of the tube, is filled by the anthers and pistil, thus warding off uninvited guests. The insect is guided to the flower by the odor and to the nectar by the slightly yellowish color near the base of the inner segments of the perianth. Insects feeding on the nectar alight on the flower and force their way to it by pushing aside the anthers; in so doing the pollen falls upon the insect, and, when it searches for food on some other plant, it comes in contact with the pistil and leaves some of the pollen. It is mostly visited by large insects, such as the bumble bee.

Visitors—HYMENOPTERA—*Apidæ: Bombus Americanus. B. vagans, Halictus coriaceus, H. fasciatæ, H. tegularia, Ceratina dupla. Stelis lateralis, Augochlora pura, Vespidæ: Odynerus foraminatus.* COLEOPTERA—*Capsidæ: Lygus pratensis,* feeding upon the pollen. DIPTERA—*Syrphidæ: Platycheirus hyperboreus,* feeding on pollen. LEPIDOPTERA—*Pamphila zabulun.*

Allium cepa. Flowers in umbels from a one or two-leaved spathe, which soon becomes dry. Flowers with a six parted perianth; segments white, with a single green rib or nerve. Stamens six, style slender with single stigma, which receives pollen from its own and neighboring stamens, but pollination is also often brought about by insects. The insects are attracted by color and the alliaceous odor which is peculiar to the plant.

Visitors—HYMENOPTERA—*Apidae: Bombus Americanus* hurriedly ran over several of the heads. *Megachile centuncularis* collected nectar and pollen. *Halictus coriaceus, H. gracilis* collecting nectar and pollen. DIPTERA *Muscidae Musca domestica. Tachina flavicaulda. Syrphidae:* Syrphus fly, with two or three other species, all feeding on pollen and aiding in pollination.

Asparagus officicinatis. L In flower during the latter part of spring and in the early part of summer, but it also blossoms later in the season in August and September, when it produces but one kind of flower, and consequently no seeds are formed. The flowers are small, green and axillary. Perianth six parted, spreading above, six stamens attached to its base, anthers turned inwards, style short, stigma three cleft. Flowers are of two kinds; that is, it has both staminate and pistillate flowers. Rudimentary stamens are found in the pistillate flowers, and rudimentary pistil in the staminate flowers. Flowers have a pleasant odor, and in spite of their green color they can easily be seen at a distance, the male flower being more conspicuous than tne female. The insect is first attracted to the male flower, after which it visits the female, and leaves some of the pollen which has adhered to its body, on the pistil; thus the flower is pollinated.

Visitors—HYMENOPTERA—*Apidae, Megachile centuncularis, Halictus tegularis, H. Cressonii, Agapostemon radiatus,* these are all the insects which I was able to secure or took note of. Hermann Mueller gives the following list: HYMENOPETERA—*Apidae: Apis mellifica, Osmia rufa, Prosopis ammilaris, Halictus sexnotatus,* collecting pollen and looking here and there in female flowers, and effecting pollination occasionally.

COMPOSITÆ.

Helianthus annuus, L. In Compositæ the flowers, being in such close proximity, it is not difficult for pollination to take place. The flowers of sunflowers are perfect, but proterandrous. The insect creeps over the head and thus causes pollination. It also, in its efforts to obtain honey, dusts some pollen on its head and thus carries it to another flower.

Visitors—HYMENOPTERA *Apidæ: Apis mellifica* collecting pollen and nectar. *Megachile centuncularis,* collecting pollen. *Nomada luteola. Perdita sp. Eucera sp.*

Helianthus tuberosus, L. Visitors—LEPIDIPTERA—*Chryspophanus thoe.* DIPTERA—*Bombylidæ: Bombyius.* HYMENOPTERA—*Apidæ: Nomada luteola,* gathering honey. *Halictus Leronxii. Melissodes perplexa,* gathering pollen and sucking honey. *Vespidæ: Odyneris foraminatus.*

Solidago speciosa. Nutt. Visitors—HYMENOPTERA— *Apidae: Bombus Virginicus,* sucking honey *Apis mellifica* sucking honey (quite abundant.) *Halictus coriaceus, Augochlora pura, Cilissa Americana, Caliopsis Andreniformis.*

Sphegidae: Crabro sp. *Ammophila conditor. Ichneumonidae: Tryphon* sp. *Lana montana* (?) *Coleoptera Meloidae: Epicauta Pennsylvanica* feeding on pollen. Hemiptera— *Phymata Wolfii. Diptera— Muscidae: Stomoxys. Mesograpta marginata.*

Cnicus altissimus. Willd. Var. *discolor*. Gray. Visitors. HYMENOPTERA— *Apidae: Bombus fervidus, B. Americanus, B. vagans. Megachile centuncularis Apis mellifica, Ceratina dupla, Melissodes bimaculata.*

MISCELLANEOUS PLANTS.

Polygonum acre. H. B. K. Small spiked flowers. Insects are attracted by its pinkish color. Flowers perfect.

Visitors—DIPTERA—*Muscidae: Calliphora vomitoria.* HYMENOPTERA—*Apidae; Halictus tegularis. Calliopsis andreniformis, Pimpla inquisitor. Sphegidae; Ammophila conditor.* HYMENOPTERA feed on honey secreted at the base of the corolla, while DIPTERA feed on both nectar and pollen.

Sedum Telephium, L. Flowers—compound cymes; petals white.

Visitors—HYMENOPTERA—*Apidae: Halictus tegularis, Sphegidæ; Ammophila conditor.*

Pontederia cordata L. Blue; spike dense, from a spathe-like bract. Perianth funnel form; two-lipped, three upper divisions united to form the three-lobed upper lip; the three lower ones spreading. The upper lobe of perianth is marked by a pair of yellow spots, which aid the insect in finding the nectar. Stamens six, the three anterior long, exserted; the posterior three with very short filaments unequally inserted lower down. Anthers versatile, oval and blue. Pistil one, with stigma turned upward.

Visitor—HYMENOPTERA—*Apidae: Halictus tegularis* feeding on nectar.

OBSERVATIONS ON THE POLLINATION OF SOME OF THE COMPOSITÆ.

BY MARY ALICE NICHOLS.

The brilliant appearance of our western roadsides and prairies from July to October, invites an extended study of the anatomy and physiology of the *Compositæ*. The wide distribution and rapid increase of this family naturally call attention to dissemination and pollination. Darwin, Herman Mueller, and others, have shown at length, the direct relation between special adaptations for cross-pollination and the race stability of plants. The question now arises, what are the opportunities for cross-pollination in *Compositae*, and to what extent is this agent a factor on the increase and distribution of the family? No attempt is here made to go into a discussion in full of these questions for the entire Family, but simply to present a few facts relative thereto, gathered from representatives of the sub-tribes *Heliantheae* and *Asterineae.*

A few observations on the common cultivated sunflower, *Helianthus annuus*, will apply equally well to all members of this conspicuous genus. First among these may be noted the mechanism of flowering. Immediately following the

bursting of the tubular corolla, the anther tube formed by the lateral union of the five anthers and enclosing the stigma, is protruded, its entire length appearing beyond the corolla tube. The anthers now dehisce liberating the stigma which forcibly protrudes itself, at the same time recurving and carrying with it, lodged in its papillose projections, numerous pollen grains. The filaments then retract drawing the empty anther tube again within the corolla. Furthermore the disk flowers open from circumference to center. Were the pollen of the outer row not potent in the fertilization of its own stigma, it must be conceded to be entirely useless so far as individual disks are concerned. Moreover, if the flowers at the center of the disk which open after the retraction of the anther tubes in the outer rows, were wholly dependent upon cross-fertilization, we might expect to find them in many cases sterile. No evidence of such a condition occurs. Hence, we conclude from its complete mechanism and from results exhibited, that in the sunflower ample provision is made for self-fertilization. But the fact that the flower is thus well equipped for its own perpetuity does not exclude the possibility of the co-operation of outside agents. The evidences of cross-fertilization by means of insects are equally numerous and conclusive. While the flowers around the border are opening, the center of the disk, glabrous with odorous resin, is a favorite resort for various *Hymenoptera*. The nectar of the flower appears to be secreted at the base of the corolla, where the style is attached. To reach the nectar it is not necessary that the proboscis of the insect be inserted inside the anther tube. Hence, it would seem at first thought quite probable that it might escape without carrying any pollen. This may in some instances be true, but it is to be further noticed that the slightest mechanical pressure at the base of the style, before dehiscence, thrusts the stigma out with an explosive effect so that a bee entering the flower at this point would be completely dusted with pollen. The complete exposure of the stigmas of older flowers would insure the deposit of some of this pollen upon them as the bee passes over. Furthermore, the fact of the legs of the insect being sticky from the resin so abundant on the disk, together with the abundance of pollen produced, would afford reasonable grounds for the conclusion that pollen is thus transported. Actual observation confirms this view and it is a well known fact that flowers of this family are subject to frequent visits from both nectar and pollen gatherers.

Sir John Lubbock in his "British Wild Flowers" shows the *Compositœ* to be specially adapted for fertilization by insects from the facts that (1) the heads are conspicuous, (2) the honey easily obtained, and (3) the small size of the florets insures the touching of many by one insect and hence effectual pollination.

Hermann Mueller also recognizes this agency and notes the special modification of certain parts in the insect for this purpose.

It is not the purpose of this paper to furnish complete lists of the insects which have been found on the species cited, but rather to point out some of those most persistent about certain flowers and determine, if possible, something as to their importance in pollination.

On *Helianthus annuus* L. by far the most frequent visitor was the common honey bee (*Apis mellifica*). This was especially true of plants growing near hives of bees, but was also true of plants observed in other localities. *Bombus Pennsylvanicus* was also a frequent visitor. It was sometimes found with its legs heavily laden with pollen, but usually it was packed into a sort of wax. This was also true, many times, of the honey bee, but in both cases loose pollen grains were found scattered abundantly over the head and body of the insect, in a position to be easily brushed off. Other visitors were *Mellisodes obliquus*, closely resembling

the bees just described, and *Diabrotica longicornis*, whose proboscis and antennæ were frequently found sticky with nectar or resin, to which numerous pollen grains adhered.

On *Helianthus grosse serratus* Martens, a very showy species which flowers in September and forms corymb like clusters, the following were found: *Diabrotica longicornis*, *Bombylini*, whose downy body and barbed proboscis were admirably adapted for transportation of pollen, and *Mordellestina comata*, a small brown beetle found in great numbers buried deep in the disk both before and after the opening of the disk flowers. The legs and antennae are slightly downy and in some cases adherent pollen occurs.

On *H. rigidus* the common visitors were *Bombylini*, *Bombus*, and *Apis mellifica*. In addition to these, Hermann Mueller gives for *H. multiflorae*: *Megachile centuncularia*, *Halictus zonulus*, *Eristalis tenax*, *Syrphus pyrastie*, and *Syrphus ribesii*.

On *H. laetiflorus* Pers. were found *Bombus Pennsylvanicus*, and *Diabrotica longicornis*. On this, as on several other members of the genus, grasshoppers frequently appeared. They were very destructive, to the ray flowers, but apparently played no part in the process of pollination.

The genera *Lepachys* and *Rudbeckia* stand so close, structurally, to *Helanithus*, as to need no special description.

On *Lepachys pinnata* Torr. and Gr., *Mellisodes obliquus* and *Phymata wolfii*, were found.

On *Rudbeckia hirta* and *R. triloba*, the only common visitor observed was *Phymata wolfii*. Since these are abundant and widely distributed species, and since this insect is one of slow movement; and, moreover, one on which no pollen was at any time detected, it seems reasonable to conclude the species of this genus are largely self-pollinating; *R. subtomentosa*, however, being sweet-scented, is frequently visited by bees (*Apis mellifica*).

In smaller heads, but scarcely less showy than the *Helianthoideæ*, is the extensive genus *Solidago*, of the *Asteroideæ*. The flowering mechanism of *Solidago* and *Helianthus* are practically the same, except that in *Solidago* the anther tube remains protruded for some time before dehiscence, and in the meantime the corolla fades. Hence the most showy period of the flower's existence occurs before the maturity of either stigma or anther. Its less attractive appearance is, perhaps, overbalanced by the distinct odor which seems intensified by the beginning of the process of decay.

Insects were observed on the following species: *Solidago speciosa* and *S. lanceolata*. The frequent visitors were *Acinandero pulchella*, *Ammophila*, and *Epicauta pennsylvanica*. Of these, the last named is so common as to be intimately associated with the flower in the minds of the most casual observers. It appears usually, soon after the deshiscence of the anther—occasionally before—and plies industriously from flower to flower, apparently finding nectar at the base of the pistil, and industriously bearing pollen from floret to floret, and from head to head.

Ammophila flits very rapidly, alighting but for an instant here and there, and affording no opportunity for observations on its motives or operations.

On other species, Mueller furnishes the following more complete lists:

On *Solidago Canadensis*,—*Eristalis arbustorum E. nemorum. Syritta pipiens*, *Sarcophaga carnaria*, and numerous small *Muscidae*. On *Solidago virga-aurea* (L.):—

Ap s mellifica, *Bombus rupestris*, *B. campestris*, *B terrestris*, *Andrena denticulata*, *Eristalis arbustorum*, *E. nemorum* and *Thecla ilicis*.

BIBLIOGRAPHY.

Allen, Grant, "Knowledge of Sunflowers," 1884.

Asa Gray, "Notes on Movements of Andrœcium in Sunflowers," Proceedings Acad. Nat. Sc., Phila., 1884, pp. 287-288.

Th. Meehan, "On Elasticity in the Filaments of Helianthus," Loc. cit., p. 200.

C. Schwartz, "Form of Stigmata Before and After Fertilization in Different Families," Pringsheim's Jahrbuch. Wiss. Botanik XV. Heft. I.

Hermann Mueller, "Fertilization of Flowers."

Sir John Lubbock, "British Wild Flowers in Relation to Insects."

ADDITIONS TO IOWA FLORA.

PROF. B. FINK, FAYETTE, IOWA.

In my collecting last summer about Fayette, I found the following plants, some of which, so far as I know, have not been reported for Iowa. Those marked with a "star" have been examined by various botanists. The others I report on my own determination:

* *Habenaria tridentata*, Hook. Borders of woods; rare.

* *H. psycodes*, Gray. Wet river banks; rare, new.

* *H. hookeri*, Torr. var. *oblongifolia*, Paine. As common as the type here; new.

Dicentra Canadensis, D. C. Woods, rare. Also reported from Decorah by E. D. W. Holway. (Proceedings Iowa Academy of Sciences, Vol. I, Pt. II, p. 16.)

MILDEWS.

In this list I have adopted the synomony given by Prof. Burrill in North American Pyrenomycetes.

SPHAEROTHECA HUMULI (D C) Burrill on *Agrimonia Eupatoria*.

S. PANNOSA, (Wallr.) Lev. on *Rosa blanda*.

*S. MALI, (Duby.) Burrill on *Pyrus Malus* also reported from Ames, by Prof. L. H. Pammel and G. W. Carver abundant on young suckers, New.

S. MORS-UVAE, (Schw.) B. and C. on *Ribes*.

S. CASTAGNEI, Lev. on *Sonchus oleraceus*.

ERYSIPHE COMMUNIS, (Wallr.) Fr. on *Astragalus Canadensis*.

E. CICHORACEARUM, D C on *Phlox Drumondii*.

*E. GALEOPSIDIS, D C on *Scutellaria lateriflora*, New.

E. GRAMIMIS, D C on *Poa pratensis*.

UNCINULA CLINTONII, Peck, on *Tilia Americana*.

U. NECATOR (Schw.) Burrill on cultivated grapes (*Vitis labruscæ*).

U. CIRCINATA, C. & P., *Acer barbatum*.

U. MACROSPORA, Peck, on *Alnus Americana*.

U. SALICIS, (D C), on *Populus tremuloides*.

PHYLLACTINIA SUFFULTA (Reb.) Sacc. on *Cornus stolonifer*, *Xanthoxylum Americanum*.

PODASPHÆRA OXYACANTHÆ (D C), Duby on *Prunus Cerasus*.
MICROSPHÆRA RUSSELII, Clinton on *Oxalis corniculata* var. *stricta*.
*M. GROSSULARIÆ (Wallr.) Lev. on *Sambucus Canadensis*. New.
M. EUPHORBIÆ (Peck), B. & C. on *Euphorbia corollata*. New.
M. ALNI (D C), Winter on *Viburnnm lentago, Syringia vulgaris*.
M. QUERCINA, (Schw.) Burrill on *Quercus rubra*.

THE PARAFFINE METHOD APPLIED TO THE STUDY OF THE EMBRYOLOGY OF THE FLOWERING PLANTS.

BY H. W. NORRIS.

These few notes are given, not that they contain much if anything new, but simply as the record of a year's experimenting. The difficulties connected with the use of paraffine in the sectioning of plant tissue are well known to all students in botanical microscopy. The cutin, cork, etc. of the cell wall resist penetration. The heat necessary to melt paraffine often renders the tissue too hard and brittle for successful manipulation. Freehand sectioning is often the only available method. Frequently this is all sufficient. Celloidin (or collodion) is available for imbedding young and soft tissues, requires no heat and its general cleanliness and easy manipulation recommends its use whenever possible. But many plant tissues are of too firm and resisting a structure to render the use of celloidin even possible. Seeds in their mature condition, will not permit the use of celloidin, and seem to almost defy the penetration of paraffine.

In attempting to study the development of ovule in the Compositæ, I was led to find some way of obtaining perfect series of sections through the flower. The forms studied were *Grindelia squarrosa, Helianthus annuus*, and a cultivated species of *Ageratum*. In most of the Compositæ the tissues of the flower become very resistant to the section knife, even at an early period. The testa of the seed is not easily penetrated by reagents. The peculiar structure of the ovule found in many Compositæ, called *éndodermis* by Hegelmaier, becomes very hard and brittle on application of heat.

Rowlee[1] obtained good sections of ripe seeds by the paraffine method, after first soaking them in water twenty-four hours before dehydration. Having seen his sections I determined to try some modification of his method. As I did not study the mature condition of the ovule, I did not soak any of the material in water.

The tissue was hardened first in 25% and then 50% alcohol, and preserved in the latter. Then as material was needed it was dehydrated in a Schultze's dehydrating apparatus into 95% alcohol, then placed in the following substances successively, one to several days each: 95% alcohol and

[1]Imbedding and Sectioning Mature Seeds, Proceedings American Society Microscopists, 1890.

chloroform equal parts, pure chloroform, chloroform with a small per cent of paraffine dissolved, increasing the percentage of paraffine from time to time, using just heat enough to to keep the solution a liquid, "soft" melted parafine, finally "hard" melted paraffine. The time required for the process was sometimes two to three weeks, but with the younger tissue, much less. As will be seen, I followed the ordinary method, but used more time. I am satisfied that many of the so-called insuperable difficulties connected with paraffine infiltration can be overcome by patience and time-serving.

Turpentine, I did not find as satisfactory a reagent as chloroform, probably because the latter will penetrate even if dehydration is not complete. I find alcohol a stisfactory hardening reagent. McClatchie recommends the use of chromic acid in hardening plant tissue. I failed to see its superiority over alcohol.

The staining was done mostly on the slide. Most of the ordinary nuclear stains worked well. The most satisfactory stains all around were Czokor's Alum Cochineal for the nucleus, and an alcoholic solution of bismarck brown for the cell wall. When managed properly saffranin gave most beautiful results. Alum-cochineal, borax-carmine, saffranin, haematoxylin, fuchsin, and picro-carmine utterly failed to penetrate the specimens in mass. Orth's lithium-picro-carmine was the only stain that penetrated in mass enough to differentiate the structure of the embryo-sac.

THE DEVELOPMENT OF THE AUDITORY VESICLE IN NECTURUS.

BY H. W. NORRIS.

Owing to the lack of a complete series of embryos, I have been unable to trace the earlier stages of the development of the ear. In all the Amphibia, so far as studied, unless we except the species of Axolotl figured by Houssay, and he was doubtless in error, the ear arises as a differentiation of the inner of the two layers into which the ectoderm is early divided. This inner sensory layer thickens on each side of the head so as to form a small sensory tract, the *unlage* of the ear, closely analogous, if not homologous, in formation to the lateral line sense organs. An ingrowth or inpushing of the thickened ectoderm results in the formation of a pit. The outer layer of indifferent ectoderm takes no share in the formation of the auditory vesicle, but it is slightly involuted into the opening of the pit. The pit deepens, its edges approach each other until the pit becomes a closed vesicle. This description applies to development of the ear of the frog as studied by Villy[1] and of the salamander, Amblystoma, as studied by myself[2].

[1] Development of the Ear and Accessory Organs of the Frog, Quart. Jour. Mic. Sci., No. CXX., 1890.

[2] Development of the Ear of Amblystoma. Jour. Morph., Vol. VII, No. 1, 1892.

The earliest stage that I have as yet found in the development of the ear of Necturus is that shown in Fig. 1. The auditory involution has just begun. In Fig. 2 the growth has proceeded so far that the pit is nearly closed. After the complete differentiation of the vesicle the ear is of a pyriform shape with the apex directed toward the dorsal part of the brain (Fig. 5). The apical portion soon becomes distinctly marked off from the rest of the vesicle as the *recessus labyrinthi* (Fig. 6). In Amblystoma I observed that the dorsal side of the primitive pit was the last to close up, thus giving support to the belief that the recessus of the Amphibian ear is strictly homologous to the recessus of the Elasmobranch ear, in which the primitive connection with the exterior is maintained through life. Just the reverse process is said, by Villy, to occur in the frog. In Necturus I have not satisfactorily decided how the recessus is formed. As the vesicle increases in size the recessus becomes more distinctly marked off, its apex grows dorsally till it lies over and upon the brain. Instead of opening into the dorsal portion of the vesicle its aperture is situated on the median side close to the brain (Figs. 8 and 10). The semi-circular canals are formed in the typical manner. As in Amblystoma the horizontal canal is the first to make its appearance. Folds of the walls of the vesicle grow in so as to imperfectly divide the ear into a number of parts: sacculus, utriculus, semi-circular canals, etc. The beginnings of the processes that result in the differentiation of the various parts of the ear are shown in Figs. 8 and 10.

The later stages have not been studied in detail, owing partly to lack of material. But this much may be stated with certainty: The ear of Necturus in its morphology and ontogeny does not differ in any important respect from that of Amblystoma. Necturus is regarded as representing a more ancestral type than Amblystoma; hence we should expect to find its organs more generalized. But it is usually unsafe to base sweeping comparisons in relationship on the similarities or dissimilarities of single organs. The sense organs connected with the various parts of the ear correspond to those in Amblystoma. But of the existence of the *pars basilaris* I can state nothing. Retzius[3] denies its existence in Proteus, the near relative of Necturus.

The orders of recent Amphibia are three. Each order has its peculiar modification of the membranous part of the ear. The ear of the Caecilians seems to be the most primitive of these, from the research of the Sarasin Brothers[4]. I find in Necturus no vestiges of the peculiarities of the Caecilian ear.

The material on which this paper is based was obtained from Miss Julia B. Platt, of Chicago University.

Explanation of figures and abbreviations used:

Au auditory involution, auditory vesicle, ear; *aug* auditory ganglion; *br* brain; *ca* anterior semi-circular canal; *ch* chorda; *ei* indifferent layer of ectoderm; *ent* entoderm, roof of mouth; *es* sensory layer of ectoderm; *mes* mesoderm; *nr* neural ridge; *opt* eye; *o* aorta; *r* recessus; *sed* dorsal fold of septum of horizontal canal; *sev* ventral fold of septum of horizontal canal.

Figs. 1, 2, 5, 6, 8 and 10 are camera lucida drawings of sections. Figs. 3, 4, 7, 9 and 11 were drawn under the writer's direction from alcoholic material, by Mr. H. G. Willard.

[3]Das Gehororgan der Wirbelthiere, Stockholm, 1881-84.

[4]*Ueber das Gehororgan* der Caecilliiden, Anat. Anz., Nos. 25 and 26, 1892.

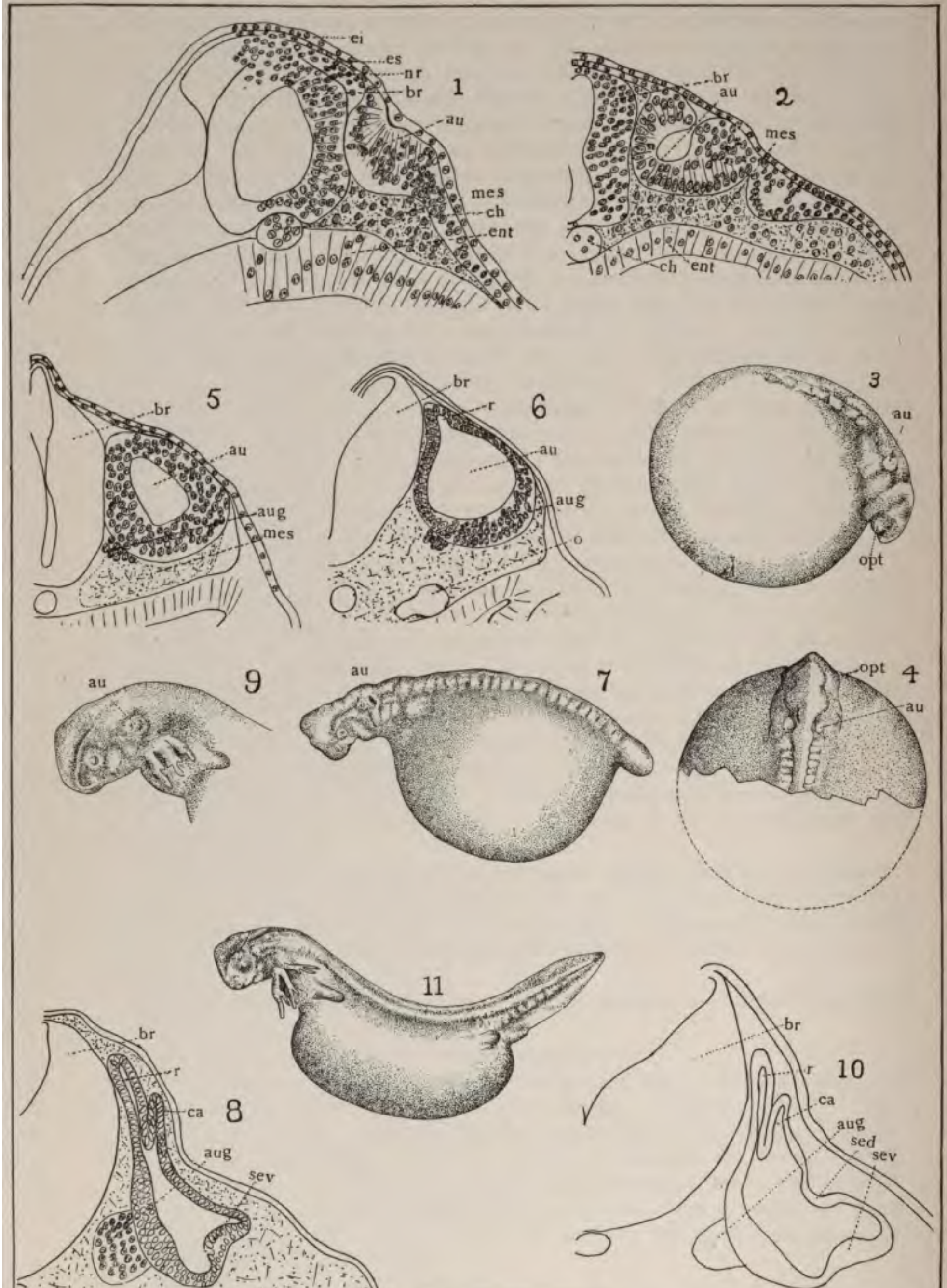

ei
es
nr
br
1
au
mes
ch
ent
br
au
2
mes
ch
ent
br
5
au
aug
mes
br
r
6
au
aug
o
3
au
opt
au
9
au
7
opt
4
au
11
br
r
ca
8
aug
sev
br
r
10
ca
aug
sed
sev
Norris & Willard del.

PLATE I.

Fig. 1. Transection of head through auditory region at time auditory involution is just beginning.

Fig. 2. Similar section of embryo of the age of the one shown in Figs. 3 and 4.

Fig. 5. Similar section of somewhat older embryo.

Fig. 6. Similar section of embryo shown in Fig. 7.

Fig. 8. Similar section of embryo shown in Fig. 9.

Fig. 10. Similar section of embryo shown in Fig. 11.

Figs. 1, 2, 5, 6, 8 and 10 are magnified 50 diameters; Figs. 3 and 4 five and one-third diameters; Figs. 7 and 9 four diameters; Fig. 11 three diameters.

AN INSTANCE OF THE PERSISTENCE OF THE DUCTUS VENOSUS IN THE DOMESTIC CAT.

BY H. W. NORRIS.

After injecting with starch-mass through the right femoral vein it was found that the entire arterial system of the cat was filled with starch. Investigation showed the presence of good sized functional ductus venosus through which the arterial and venous systems communicated. The individual possessing this peculiarity was, in life, troubled with what is vulgarly called "fits," whatever that may have been in this particular case. I should be loth to admit any relation between "fits" and the presence of a functional ductus venosus without more extended data.

ADDITIONAL NOTES ON IOWA MOLLUSCA.

BY B. SHIMEK.

About five years ago the writer published an annotated list of Iowa *Mollusca** under the title "*The Mollusca of Eastern Iowa.*" Material has been secured since by which many of the species have been traced across the entire State, and which also throws much additional light on the synonymy of some of the species.

Without an attempt at a thorough and complete revision of the former list a few notes on species heretofore mentioned are presented, and a number of species which have been collected or recognized in the State since the

*Bulletin from the Lab. of Nat. Hist. of the State University of Iowa, Vol. I, No. 1, November, 1888.

former publication, are included. These notes are presented in the following annotated list:

Family STREPOMATIDÆ.

Genus Goniobasis.

G. livescens, Menke.—In the former list *G. cubicoides,* Anth. is reported on the authority of Prof. Witter. Mr. Keyes also reports it*. Since the publication of the name about 100 specimens of a *Goniobasis* which was collected in the Des Moines river, at Humboldt, by Mr. L. B. Elliott. were received. Most of them agree exactly with the description of *G. cubicoides,* but a comparison of the entire set with authenticated specimens of *G. livescens,* Mke. from Michigan, Indiana, and New York leaves no doubt that they are the same. The specimens from Humboldt are, therefore, referred to *G. livescens,* Mke.

Family RISSOIDÆ.

Genus Pyrgulopsis.

P. scalariformis, Wolf.—The identity of *P. mississippiensis,* Call and Pilsbry, reported heretofore, and Wolf's species have already been established by me.†

Family VIVIPARIDÆ.

Genus Campeloma.

In the former list three species were admitted: *C. decisum,* Say, *C. subsolidum,* Anth., and *C. rufum.* If we accept Call's revision of the genus‡ two other specimens (?) should be admitted, namely *C. integrum,* Say, and *C. obesum,* Lewis. I cannot, however, see any valid reason for recognizing all these "species" and feel like exclaiming with Mr Simpson: "Why name anything that has neither beginning nor end?" These shells form a series of which the narrower, more elongated *C. subsolidum* and *decisum* form one extreme, *C. integrum* is a form usually intermediate and *C. rufum* and *obesum,* proportionately wide forms, represent the other extreme. Extreme, or "type" forms are apparently distinct, it is true, but there is such a gradual transition from one form to the other that the student who would attempt to separate a large number of specimens soon becomes inextricably tangled. In this connection I would speak with the least assurance of *C. decisum* as it is possible that the Iowa forms which have been variously referred to in this species are merelv variations of *C. subsolidum.* *C. subsolidum* and *C. obesum* connect closely by intermediate forms, and *C. integrum* cannot be separated from either satisfactorily.

C. rufum, in its extreme development, seems to be very distinct, but in a large series of the form obtained at Cedar Rapids, where I have collected it in the Cedar river during almost every one of the past eleven years, the pink color of the apex and interior of the aperture and the sculpturing of the surface are by no means the reliable characters which they are represented to be, and the form grades insensibly into *C. obesum.* It seems that Mr. Binney's disposition of these forms‖ is still the best, and that all should

*An Annotated Catalogue of the Mollusca of Iowa.—Charles R. Keyes, in Bulletin of the Essex Institute, Vol. XX, 1889.

†Bull. Lab. Nat. Hist. S. Univ. of Iowa, Vol. I, No. 2, June, 1892.

‡On the Genus Campeloma, R. Ellsworth Call—Bull. Wash. Call. Lab. Vol. I. No. 5.

‖*Land and Fr. Water Shells* of *N. Am.*, part III.

be grouped under *C. decisum*, Say, if that form is a part of the series, or under *C. integrum*, Say, if the former is distinct. Reversed specimens of *C. rufum*, *subsolidum* and *obesum* have been collected.

Family ZONITIDÆ.

Genus Zonites.

The Lœss fossil which was reported in the former list under the name *Z. limatulus*, Ward with the suggestion that it is probably distinct has since been described by Mr. H. A. Pilsbry, under the name *Z. shimekii*. A large series collected in the Lœss of Iowa and Nebraska shows this to be very constant in its characters.

Family HELICIDÆ.

Genus Vallonia.

In the former list two forms were reported: *V. pulchella*, Muell, and *V. pulchella costata*, Muell. Dr. Victor Sterki, who has recently published an extensive monograph of the genus* recognizes four species among the forms occurring in Iowa. They are:

V. Pulchella, Muell—The large, smooth (ecostate) form with nucleus smooth.

V. gracilicosta, Reinhard—Equally large or larger, but with distinct costæ and nucleus spirally marked with faint ribs or lines.

V. parvula, Sterki—Small; ribs prominent; nucleus with fine revolving lines; body-whorl not descending to aperture above. Lip reflexed.

V. perspectiva, Sterki—Small; ribs prominent; nucleus without lines; body-whorl descending to aperture; lip none, or only slightly expanded.

Of these *V. pulchella* is the form formerly recognized by that name, while the last three were collectively included under the *var costata*, specimens of *gracilicosta* being also mingled with *V. pulchella*.

I have specimens of *V. pulchella* as here restricted from Iowa City and Muscatine.

V. gracilicosta, Reinhard, was collected by me at Eastport, in Fremont county.

V. parvula, Sterki, is the form which was most commonly sent out as *var. costata*. It is very common at Davenport, Muscatine, Iowa City and Eastport. This is clearly a distinct species, not like *var. costata*, as comparisons with European specimens of the latter clearly show. It is not at all difficult to distinguish between this and *V. pulchella*, and the only wonder is that they were ever united.

V. perspectiva, Sterki—Four specimens of this species were sent to Dr. Sterki from Eastport. A microscopic examination of a large number of shells shows that the markings of the nucleus and the deflection of the body-whorl are not always satisfactory characters and it may be necessary to consider *V. perspectiva* a variety of *V. parvula* and perhaps *V. gracilicosta* a variety of *V. pulchella*, unless other characters than those enumerated should determine otherwise.

Family PUPIDÆ.

Of the species heretofore reported, the following have been found at Eastport, Fremont county: *Pupa armifera*, *contracta*, *pentodon*, *fallox* and *milium*, and *Vertigo ovata*. *Vertigo milium* should have been *Pupa milium*

*Observations on Vallonia, by Dr. V. Sterki.—Proc. A. Nat. Sc. Phil. May 30, 1893.

and *V. simplex* is *Pupa edentula alticola*, Ingersoll. The following are additional species:

Pupa curvidens, Gld.—Found at Iowa City and Eastport. Rare.

Pupa edentula, Gld.—Two living specimens of this species were found at Iowa City.

Pupa procera, Gld.—This species, which is usually distributed under the name *P. rupicola*, Say, is common in Fremont county at Eastport, and one specimen was found at Iowa City.

Pupa holzingeri, Sterki.—Very common at Iowa City, Davenport (Prof. Sheldon) and Eastport. One specimen from Eastport is reversed.

Vertigo tridentata, Wolf. Rare at Eastport. Not rare at Iowa City. This was reported as *V. gouldi*, Binn.

Vertigo bollesiana, Morse. Iowa City and Eastport. Rare.

Family SUCCINIDÆ.

The form reported as *Succinea higginsi*, Bld. cannot be considered as distinct from *S. ovalis* and should be dropped from the list. The very large form heretofore referred to *S. avara*, which is common in low lands and as a fossil in the Loess, and which sometimes approaches *S. obliqua* in size, is probably entirely distinct from *S. avara* and all described species. A thorough study of the shells and anatomy of this form will be made as soon as possible in order that this point may be settled.

Succinea lineata, W. G. B. should be added to the list. It is common in the Loess westward, and a few bleached though probably recent specimens were found near Hamburg, Fremont county.

Family AURICULIDÆ.

Genus Carychium.

C. exiguum var. exile, H. C. Lea. This slender form is common at Iowa City and Eastport, and probably in all other portions of the State in which *C. exiguum* occurs.

Family LIMNÆIDÆ.

Physa lordi, reported on the authority of Call, should be dropped from the list. The specimen proved to be a deformed *P. heterostropha*, Say.

Planorbis albus, Muell., reported as rare and only in the northern part of the State; is common in "Cedar Lake" at Cedar Rapids.

Family CYRENIDÆ.

Genus Sphærium.

Twelve species were reported in the former list, but this number must be cut down. *S. solidulum*, Pr. is without doubt *S. sulcatum*. Extreme forms differ, but a great number of immediate links can easily be found. *S. stamineum*, Con. as reported, were old *S. rhomboideum*. The specimens were named by Call, and included in the list on his authority. Comparison with a series of *S. rhomboideum*, since dredged in the same pond, shows that the shells were old, heavy *S. rhomboideum*.

The true *S. stamineum*, Con. is common at Iowa City, but after an examinaton of several quarts of specimens I cannot distinguish this from *S. striatinum*, and more than that the *S. sulcatum* and *S. striatinum* series often approach so close together that it is almost impossible to satisfactorily place some species.

S. fabulis, as reported, is an extreme form of *S. solidulum.* It should be dropped from the list.

S. partumeium, *S. jayanum*, and *S. sphoericum*, as identified by Prof. Witter, also from one series, and are the same species, *S. sphæricum* being intermediate. Our specimens are not typical *S. partumeium*, but resemble typical *S. jayanum* more nearly. If *S. partumeium* should prove to be a valid species, which is doubtful, then all of our specimens (including *S. sphaericum* as identified by Prof. Witter) must be referred to *S. jayanum*, Prime.

This leaves seven species of *Sphaericum* in the State: *S. sulcatum*, *Lam.*, *S. striatinum*, Lam., *S. rhomboideum*; Say, *S. jayanum*, Prime, *S. transversum*, Say, *S. secure*, Prime, and *S. truncatum*, Lius.

Mr. Charles R. Keyes, in the list already referred to, also reports the following additional epecies:

Tridopsis palliata, Say.
Ancylus tardus, Say.
Ammicola orbiculata, Lea.

VARIATION IN THE SUCCINIDÆ OF THE LOESS.

BY B. SHIMEK.

The recent species of the genus *Succinea* are certainly puzzling, but those which are found as fossils in the loess deposits of the Missouri and Mississippi valleys are positively bewildering. The fossil forms belong principally to the *avara* and *obliqua* groups, but few specimens belonging to the *ovalis* group occurring. Without entering into a detailed discussion of the various forms it may be briefly stated that an examination of the specimens, both recent and fossil, which are herewith submitted, will show the following facts:

The three forms which are commonly found in the loess are *S. obliqua*, Say, *S. avara*, Say *S. lineata*, Binn. A careful weighing of the variation in the recent specimens of these species, supplemented by the almost unbroken series of fossil forms, shows that typical *S. avara* varied through the larger form of the same species to *S. obliqua* in one direction, with a smaller branch running into *S. lineata* in another. In other words, I am convinced that however different these species may appear now, they were once the same, the original stock occurring perhaps just before the loess.

The variation in these forms, or in the original form, was not the result of climatic conditions, for all forms often occur in the same deposit.

It is expected that a more complete report on this variation, with proper plates, will be elaborated in the near future.

It may be of interest to note that our small typical fossil, *S. avara*, is identical with *S. oblonga*, Drap., from the loess of Germany.

THE JOHNS HOPKINS BIOLOGICAL LABORATORY

W. S. WINDLE

For the past fifteen years it has been customary for the members of the biological department of Johns Hopkins University to devote their summer vacations to pursuing their studies upon the sea shore, where living marine animal forms may be secured for daily use.

The Johns Hopkins Marine Laboratory, as the organization is called, is under the direction of Prof. W. K. Brooks, and has been confined to no permanent location, but has been moved about from place to place as the wishes of those most interested demanded. The work of many seasons was devoted to the study of forms found in the waters of the Chesapeake Bay. For six years the laboratory was stationed at Beaufort, N. C. Then three summers were spent in the waters which bathe the shores of the Bahamas; Green Turtle and Binning islands having been chosen as stations for biological research. Finally the organization went as far south as the island of Jamaica, upon the coast of which it has spent two seasons.

The site of the present marine laboratory is Port Henderson, a private seaport on the south side of the island. It is a quaint old village of a dozen buildings or more, used as a seaside resort for Jamaicans of leisure and wealth. A more attractive and suitable spot in that vicinity could not have been found for our party of seven.

In the immediate rear of the village Salt Pond Hill rises abruptly to a height of 1,000 feet or more, and upon its highest point are the ruins of an old stone fort known as Rodney's Lookout. Here, in the early days of pirates and buccaneers, Admiral Rodney had his stronghold, whence he could look out upon the harbor and open sea and detect the approach of hostile visitors. From the verandah of our laboratory, which was within a stone's throw of the sea, we were afforded a grand view of Kingston Harbor, in which the entire fleet of the English navy might anchor with safety. To the north of the village the low sandy beach extends past the village of fishermen's cabins, and beyond old Fort Augusta to the Rio Cobra river. Across the harbor, four miles away, Kingston, the capital of the island, appears in dim outline. Across the neck of the harbor, two miles to the southeast, the old town of Port Royal stands upon the end of a low, narrow promontory, known as the Pallisadoes. To the south the shore rises rapidly to form a steep, rocky and dangerous coast. Between this coast and the pallisadoes, the harbor opens out into the deep waters of the Caribbean Sea. The beautiful landscape stretched out thus before us was completed, from an artist's

standpoint, by the Blue Mountain range, which formed a dark gray background to the east and north, leaving the boundless sea to meet the horizon in the southeast.

The building which we termed our Marine Lab. was a large one-story stone structure known as the "Sister-Houses." It was light, airy and comfortable, affording ample room for our party of seven. Each member of the company occupied a separate table and upon this his microscope was placed, together with a varied collection of specimens, preserving fluids, dishes, aquaria, scalpels, needles, pipettes, etc., the whole forming a veritable biologist's corner. It was through the kindness of Dr. Brooks that we secured a temporary loan from the Johns Hopkins Biological Dept., of all the necessary chemical reagents, general apparatus, many valuable books of reference, etc., to equip our seaside laboratory very fully and satisfactorily. We had a sloop and light row boat at our command, also the services of a native boatman. While we were supplied with more than that needed for our immediate wants, yet a steam launch and apparatus for deep sea dredging by steam power, would have been very acceptable. It is hoped that these additions will be made during next season.

The location at Port Henderson offers many facilities for biological research. Numerous small coral islands, so called Cays, from two to ten miles out at sea, are rich in Crustaceans, Anemonae, Ophiurans, Astrophytons, Serpula, Terebrella and numerous species of Alcyonaria, Astraea and Madrepora. Near Port Royal were numerous mangrove ponds—where the bushes hang extended into the shoal water so as to form ponds and channels of quiet sea water—we found life very abundant there. Clusters of Clavelina, Simple Ascidians and colonies of hydroids grew upon the mangrove roots in endless profusion, while star fishes, sea urchins and Holothurians were abundant.

A large salt water lagoon two miles south of our laboratory and along the coast was inhabitated by numerous crocodiles and turtles. There we also found a large jelly fish—cassiopoea in abundance; also gasteropods and crustaceans. The surface collections in the bay afford an endless variety of forms for study. Good opportunity for work is also found on land. The hill in the rear and the broad valley ot the Rio Cobra river not far away are stocked with land crabs, lizards, termites, scorpions, etc. Bird life is not so abundant as we had anticipated, and the herpetologist will find no snakes, but only the mongoose in their places. The flora of Jamaica is rich and varied; ferns, palms, crotons and cacti predominating.

By those best acquainted with the coast of Jamaica, the site of Port Henderson is considered to be the most suitable location on the island for a permanent marine laboratory As indicated above, it offers superior advantages for study of animal forms in the tropical waters. Situated in the immediate vicinity of Kingston all the temporary needs of the school may be readily supplied. It is also in direct communication by steamer and cable with New York and Liverpool. The location affords such general satisfaction that prominent biologists at home and abroad have considered plans for establishing a permanent international marine biological station at that place. It is sincerely desired that all preliminary steps taken in this direction may lead ultimately to the establishment of the much needed institution on American shores.

A complete report of the various expeditions taken by our party with detailed accounts of collections taken, also of the work of each student, explaining his methods of preserving and studying material, would require more time than the present occasion admits; suffice it for the present. to submit the following:

PRELIMINARY NOTES ON PELAGIC ANIMALS FOUND IN KINGSTON HARBOR.

The only suitable times in the day for surface collecting were early in the morning or late in the evening, when neither land nor sea breeze disturbed the placid surface of the water. Our outfit was quite simple, consisting of a light row boat, two water pails and two nets of fine silk bolting-cloth. The nets were similar to dip nets in shape; no handle, however, it being replaced by a long cord arranged to draw the net horizontally through the water. When engaged in surface-collecting we usually rowed out upon the bay a half-mile or more from shore, then threw over the nets to drag from the stern of the boat. Richest collections were taken when the rims of the nets extended partly out of the water, so as to skim the surface to a depth of twelve inches.

Huxley recommends following the "plancton streifen" or trails of "dead water," but we found so much debris from the shores in these trails that we abandoned them, although richer in animal and plant life than other places. The nets were emptied every few moments in the pails which were one-half full of fresh sea water. After about an hour's rowing we returned to shore, filled the pails with fresh sea water and repaired directly to the laboratory. The catch was examined in a preliminary way, very hastily, by dipping out small portions in glass dishes. These were held toward the light of a window or lamp, when swarms of pelagic forms appeared, swarming about in great confusion. If desirable specimens appeared they were transferred by means of a wide-mouthed pipette to small aquaria of fresh sea water, or put directly into the fixing reagent previously prepared. Small jelly-fish and Ctenophores were removed very carefully by means of deep watch-glasses.

Among the countless multitudes of varied forms taken we found larval crustaceans predominating. Representatives of the Nauplius, Zoea and Megalops stages were all present, a few only of the best, however. Larvæ of shrimps (Palæmonetes), land crabs (Maji), lobsters (Homarus), rock-crabs (Cancer), Stomatopods, etc., were among those present. Of adult crustaceans we found Copepods, Lucifers, Phyllopods and Ostracods. No Nebalia were taken. Numerous Plutei of Ophiurans and Sea Urchins (Strogylocentrotus), also a few Bipinnaria were collected in early part of July. Sagitta represented the Annelids chiefly, while Appendicularia alone of the Tunicates appeared,—no Salpa being found as at Binning, Woods Holl, and other places. A number of Cœlenterates were always collected in the "tow"—*i. e.*, Medusa of Obelia, sections of Diphyids, Aurelia, a few planulæ, Irene, etc.

Large Ctenophores (Cydippidæ) continually annoyed by their presence. Larval fish, in various stages of development, also minute adults were frequently caught.

It is interesting to note the fact that plant life was richly represented in the "tow" by numerous species of Algæ, Diatoms, species of Protococcaceae, also Trichodema were determined.

In preserving the delicate larval forms alive in aquaria, for study we found difficulty, and only succeeded by using large glass dishes (scrupulously clean) They were kept from direct sunlight and the water was changed or fresh quantities added every three or six hours, as the case might require.

Several methods were adopted for fixing and preserving the material, according to the character of the specimens in hand.

Medusæ were successfully prepared by—

1. Placing into solution, until they sink to bottom:

$$\left\{\begin{array}{l} 10\%\ CuSO_4 - 100 \text{ c. c.} \\ \text{Sat. sol. } Hg\,Cl_2 - 10 \text{ c. c.} \end{array}\right.$$

2. Into 5% $K_2Cr_2O_7$—1-7 days.
3. Wash thoroughly in water.
4. Graded alcohols, 35-90.

Larger Jelly-fish and Ctenophopes were preserved for histological purposes by using—

1. Erlicki's fluid, 6-10 days.
2. Wash in water slightly acid.
3. Graded Alcohols, 33-90.

Crustacean larva were treated.

1. Sat. aq. sol. $Hg\,Cl_2$—5 minutes.
2. Wash with 33% alcohol and transfer through graded alcohols to 90%.

Other methods were tried but best results were obtained by using those above described.

Surface collections from tropical waters are intensely interesting to the student of animal life. There in the surface water of the sea he finds the great nursery of marine forms, both plant and animal. Further, we are informed, sufficient reason warrants the statement that, likewise, all living forms had origin in minute, free-swimming organisms upon the bosom of the ocean in past ages. A candid study of the life histories of typical animals—in which they pass from a simple cell through various metamorphic stages to the adult forms—confirms the doubtful in the doctrine of evolution. And a true conception of relationships existing between members of so called families reveals the truth of the oft repeated statement, that "the ocean is the original haven of all life." The more we become conversant with marine life the more definitely are we impressed with the fact that it is from that source we must ask further information, that shall throw light upon many Biological problems at present unsolved.

THE VASCULAR SUPPLY OF THE TEETH OF THE DOMESTIC CAT.

C. C. NUTTING, IOWA CITY.

After all that has been written about the anatomy of the domestic cat it would seem a hopeless task to find any facts of real importance in a field so carefully gleaned by Wilder and Gage and a host of other writers of the past and present.

While pursuing investigations on the teeth of the mammalia as a preparation for lectures on Comparative Odontography before the Dental Department of the State University of Iowa, the writer became convinced that there were certain radical misconceptions among anatomists and histologists as to the manner in which the blood is distributed to the teeth. It is quite possible that this has already been correctly stated by some writer unknown to me. If such is the case it is evident that little heed has been given to the matter by English and American authorities, among whom I have been unable to find a single clear and lucid, as well as correct account of the vascular supply of the teeth. This, then, is my excuse for adding to the already multitudinous contributions to the anatomy of the domestic cat. Dissections and microscopic preparations of injected decalcified teeth of the cat, and also of the rat, in which the entire jaw with all the teeth has been ground down to the requisite thinness, show conclusively that the manner in which the teeth obtain their vascular supply is not understood or at least not properly expressed by the best authorities accessible to the student.

This matter obtains a further importance in view of the strong probability that there is no great difference between the human and feline anatomy in this particular, and a likelihood that the errors in the one case have been paralleled in the other.

First—What is the present teaching as to the method by which the teeth are supplied with blood? The following quotations will be sufficient to answer this question.

[1] "The pulp contains the nerves and blood vessels of the tooth, which pass into the pulp through the foramen at the point of the fang." [2] "This (the pulp cavity) communicates with the external surface of the tooth by a small aperture at the apex of the root." [3] "The blood vessels and nerves penetrate by a little orifice at the extremity of each root." [4] "The vessels of the pulp are very numerous; three or four arteries enter at the apical foramen." [5] "The lower teeth derive their vascular supply from the branches given off to each tooth by the inferior dental artery, itself a branch of the internal maxillary." [6] "The pulp consists of a soft connective tissue, and some nerve fibres which pass into the pulp cavity along with the blood vessels by a minute canal at the apex of the fang." [7] "The arteries and nerves, which are derived from the internal maxillary and fifth pair respectively enter by the aperture at the point of each fang." [8] "The dental and incisor arteries during their passage through to the substance of the bone give off a few twigs which are lost in the cancellous tissue, and a series of branches which correspond in number to the roots of the teeth; these enter the minute apertures at the extremities of the fangs and supply the pulp of the teeth."

Dr. G V Black, in his work on the periosteum and peridental membrane, comes nearer a correct statement of the manner in which blood is supplied to the teeth than any other writer whom I have been able to consult. He says:

[1]Prof. Wm. Turner, Enc. Brittanica, Vol. VII., p. 234.
[2]Prof. W. H. Flower, Enc. Brittanica, Vol., XV., p. 349.
[3]Human Physiology, Flint. p. 191.
[4]Dental Anatomy, Tomes, p., 106.
[5]Dental Anatomy, Tomes, p 36.
[6]The Essentials of Histology, Schafer, p. 128.
[7]Quain's Anatomy, Ninth Edition, p. 550.
[8]Gray's Anatomy. p. 523.

"The blood supply of the peridental membrane is very bountiful in the young subject. The larger arteries enter the alveolus mostly at the apical space, or rather one or two vessels enter here and immediately break up into smaller ones. One or two of these enter the root canal to supply the pulp of the tooth, while the others, from four to six or eight, pass down along the sides of the root to supply the peridental membrane. In their passage down the membrane these divide into many branches, a considerable number of which enter the haversian canals of the alveolar wall or receive branches from that source."[9] My own sections convey a somewhat different impression. By far the greater number of arteries enter the alveolus in the spaces between the roots, of molars, and none of these, so far as I can discover, go directly to the root canal and thence to the pulp. A very large number of vessels enter the peridental membrane from the entire extent of the alveolus.

Dr. Black seems to have drawn his conclusions largely from sections of teeth of the lower animals, such as the sheep, dog, cat and pig. Indeed, I can find no one who seems to have made a special study of injected human teeth ground down in situ. The extreme difficulty of securing suitable material for such investigations may account for this fact.

From the above quotations, which give all that is said on the subject by a number of our best and most recent authorities, it is evident that they understand the blood to be supplied to the teeth in the following manner:

The internal maxillary and inferior dental arteries supply the teeth of the upper and lower jaws by giving off a branch to each root, the branch entering by a single aperture at the apex of the root. We are also given to understand, although definite statements seem painfully deficient, that the branch which supplies each root passes from the main artery (internal maxillary or inferior dental), directly through the peridental membrane, and thence through the single apical foramen to the pulp. The present writer considers that he has demonstrated an essentially different method of supplying the blood to the teeth; at least of the domestic cat and the rat. The points of special importance are:

First. The inferior dental artery is not a single vessel; on the contrary, after entering the inferior dental foramen, it divides, within the canal, and the divisions anastomose and redivide in the most irregular and perplexing manner.

Second. There is nothing at all resembling the single branches of this artery which are supposed to be given off to supply each root; on the contrary, by far the largest and most numerous branches of this artery pass into the alveolar spaces between the roots of the teeth, and then break up into a maze of small vessels, most of which ultimately pass into the peridental membrane, considerably above the apex of the root.

Third. No vessels, so far as my series of sections shows, pass directly through the peridental membrane below the apex of the root, and thence upward into the pulp. On the contrary, a multitude of vessels enter the peridental membrane throughout its extent and pass downward toward the apices of the roots, where they enter foramina, through which the pulp is reached. The blood is thus distributed, first to the membrane, which is exceedingly vascular, then conducted by vessels in the membrane to the apices of the roots.

[9]Periosteum and peridental membrane, Black, p. 85.

Fourth. The blood does not ordinarily enter each root by means of a single apical foramen as commonly taught. On the contrary there are usually several, sometimes more than a dozen such foramina in a single molar root after the animal has reached maturity.

The above statements indicate such a radical change of view regarding the vascular supply of the teeth that something more satisfactory than mere assertions will doubtless be expected. In order to meet this reasonable expectation the illustrations accompanying this account have been prepared with considerable care. The sections from which the drawings are taken are injected and not decalcified, and were prepared by the writer, who still has them in possession. It will be understood that the views here advanced are based on numerous dissections and sections besides those illustrated by the drawings.

It was found that drawings were more available than photographs, for the reason that the thickness of the sections and the irregularity of the vessels required a depth of focus which could not be secured by use of the camera. Although all drawings are necessarily interpretations of the artists views, it is hoped that there is nothing misleading in the illustrations herewith presented. They may be considered correct in so far as they do not represent a single vessel pursuing a course not found in the sections examined.

In conclusion, your attention is called to the fact that this matter has a practical bearing. The teeth of the Carnivora, as Owen says, so closely correspond in their intricate structure both with each other and with those of the "Quadrumana" as not to require separate discussion. More than this it is highly improbable that there should be any essential difference between the teeth of the cat and those of man in the method of furnishing blood to this important structure.

Dr. A. O. Hunt, dean of the dental faculty of the State University, says that the excessive hemorrhage sometimes attending extraction of the teeth is due to the breaking of the septum between the teeth, which, as my sections show, contains large branches of the dental arteries. If these arteries penetrated directly to the pulp through the root excessive hemorrhage would always result from the pulling of the tooth. It makes a vast practical difference whether a multitude of minute vessels or one large vessel is broken. In the former case, little hemorrhage would result, while in the latter it would be a serious matter. These sections are necessarily thick, as thin sections would fail to show the continuity of the vessels, a vital point in the investigations upon which this paper is based. The sections, although quite thick, were rendered sufficiently translucent by long immersion in benzole, after which they were mounted in Canada balsam.

Fig. 2.

Fig. 1.

PLATE II.

FIG. 1. Vertical longitudinal section of lower jaw and teeth of cat, showing vascular supply.

FIG. 2. Vertical longitudinal section of roots of two lower molars and underlying portion of jaw of cat, showing anastomosing branches of the inferior dental artery. Drawn from section made by author.

THE HOMOLOGY OF THE "INCA" BONE.

BY C. C. NUTTING.

About two years ago, while examining the interesting series of prehistoric skulls in the collection of the Davenport Academy of Sciences, the writer became involved in an attempt to account for the supernumerary bone which some one has marked the "inca" bone. What the significance of the name may be, I do not know, but the significance of the *fact* is the object of the inquiry involved in this paper.

In a series of about twenty skulls examined by me there were at least six which exhibited the so-called "inca" bone, which is a portion of the occipital, separated from the remainder by a very distinct suture extending across the bone, following the "superior curved line," and about one-half inch above it. This suture is quite constant in position in every skull showing the "inca" bone.

The portion of the occipital which is thus cut off shows a tendency to itself divide into two or three pieces. But the sutures in this case are not constant in position and may, in fact, occur in almost any portion of the "inca" bone.

In attempting to homologize this peculiar bone, three possibilities occur:

First—The inca bone is the homologue of the supraoccipital of certain of the lower mammalia.

Second—The inca bone may be simply an enormously developed wormian bone.

Third—It may be a persistent embryonic character.

As to the first hypothesis, *i. e.*, that it is the supra occipital, we find that the supraoccipital in lower mammalia reaches to and forms part of the borders of the foramen magnum. The "inca" bone, on the contrary, is always remote from the foramen magnum, being above the superior curved line. It can thus be seen that the bone in question cannot be the supra occipital.

The second hypothesis, *i. e.*, that we have here merely an enormously developed wormian bone, would, at first thought, seem to be unworthy of serious consideration. But Gray[1] says, in his classic Anatomy:

"They (the wormian bones) vary much in size, being in some cases not larger than a pin's head, and confined to the outer table; in other cases so large that one pair of these bones may form the whole of the occipital bone above the superior curved lines."

This is the extent of the "inca" bone in all cases, and in at least one

[1]Gray's Anatomy, Eleventh Edition, p. 184.

skull, No. 2 in the sketches, the inca bone is vertically divided into two by a suture a little to the right of the median line. It is probable that if this particular skull were placed in the hands of Dr. Gray he would consider the "inca" bone enormously developed wormian bones. It seems to me, however, that there is a more natural explanation and one more in accord with the facts.

I have here the tabular portion of the occipital of a well advanced human fœtus. It is what would correspond to the supraoccipital of some of the lower mammalia. The bone is cleft on each side, the fissure being just above what will ultimately be the superior curved line. Looking on the inside of the bone, there are indications that at a still earlier stage of development this bone was separated into two parts, the separation being along a line a little above the superior curved line. This is exactly the condition of affairs found in the skulls with the "inca" bone. In other words, we have in the ordinary human embryo a condition of affairs which we find in the adult skulls of these prehistoric people. It seems likely, therefore, that we have here a persistent embryonic character.

Unfortunately I was unable to find any satisfactory record of these skulls in the catalogue of the Academy. Most of them were simply entered by number. One was marked "De Kalb Co., Ill.," and I was told that it and several others came from prehistoric graves in that locality.

If the "inca bone" was a characteristic of a definite race of human beings, it would certainly be sufficient to constitute a new species of the Genus *Homo*. If it was only an occasional, or even somewhat frequent abnormality, it may be regarded simply as a "reversion" indicating that the race possessing it was of a peculiarly low type.

NOTES ON THE DISTRIBUTION OF HEMIPTERA.

BY HERBERT OSBORN.

During the past few years I have received from a number of different sources, partly by purchase and partly by sets sent me for determination, a number of collections of Hemiptera, and as some of these records extend the known distribution of the species, or give more specific data regarding them, it seems desirable to give them a permanent record.

The principal collections on which the paper is based, aside from my own, are those made by Mr. Wickham in New Mexico, Arizona and California, and in the northwest, and purchased by the Agricultural College or by myself, those from Prof. C. P. Gillette, of Colorado, Prof. Lawrence Bruner in Nebraska, Prof. V. L. Kellogg in Kansas, Dr. C. M Weed in New Hampshire, and others.

The Hemiptera present us with a number of interesting cases of distribution. In some cases apparently dependent upon food plant, in others

upon climate or temperature, but in some independent of any apparent condition. With some of the species it may be an endless task to determine the conditions which most affect their geographical distribution, and in such cases it is probably a combination of influences and no single one that determines their range.

Some of these notes were presented in a paper, abstract of which appears in part I, page 64, the full paper never having been published. Since the presentation of that paper, however, I have examined a number of collections and much increased the list of species mentioned, as well as the number of localities recorded.

Eurygaster alternatus Say. Mass., Iowa; Wyoming; Huntington, Oregon. Coeur d'Alene, Idaho; N. H.

Corimelæna atra Am. et Serv. Colorado.

Corimelæna albipennis Say. Colorado. Probably rare. Seems not to have been recognized since Say's description till a specimen came into my hands from Prof. Gillette.

Pangaeus bilineatus Say. Dallas, Oregon.

Amnestus spinifrons Say. Colorado.

Perillus splendidus Uhl. Colorado.

Perillus exaptus Say. Winnipeg.

Perillus claudus Say. Albuquerque, New Mexico; *var.* Huntington, Oregon; *var. c* Say. Colorado.

Podisus cynicus Say. Ill., Tenn., Tex., Colorado.

Podisus placidus Uhl. Colorado.

Podisus spinosus Dallas. Williams, Ariz.

Liotropis humeralis Colorado. Specimens from that state are larger than those collected in Iowa.

Prionosoma podopoides Uhl. Colorado and southwest.

Podops dubius Pal Beauv. Colorado. The specimens from Colorado seem to agree better with dubius than with *cinctipes* which is credited to the United States, while dubius is given in Uhler's check list as belonging to the West Indies.

Brochymena annulata Fab. Colorado.

Cosmopepla carnifex Fab. New Hampshire.

Cosmopepla conspicillaris Dallas. Colorado; Vancouver Island.

Mormidea lugens Fab. New Hampshire.

Euschistus fissilis Uhl. Colorado; Tacoma, Wash.

Euschistus tristigmus Say. Colorado; New Hamphire.

Euschistus impinctiventris Stal. Portland, Oregon.

Euschistus variolarius Pal Beauv. Albuquerque, New Mexico; Colo.

Lioderma ligata Say. Seligman and Williams, Arizona.

Lioderma sayi Stal. Seligman, Arizona.

Peribalus limbolarius Stal. Albuquerque, New Mexico; Colorado.

Thyanta rugulosa Say. Winslow, Arizona; Needles, California.

Thyanta custator Fab. Colorado.

Thyanta perditor Fab. S. Dakota.

Murgantia histrionica Hahn. Barstow, San Diego, Cal.; Albuquerque, New Mexico. This species is distributed very generally over the southern portion of the country extending from New Jersey on the east to southern California on the west. It was at one time feared it would overrun the

northern states, and Prof. Riley some twenty years ago and other writers more recently have predicted such a danger but it would surely have as good an opportunity in the Mississippi valley as anywhere and the fact that it has made no advance to speak of in the last twenty-five or thirty years seems good evidence that it has a pretty definite southern limit. It will doubtless remain a serious pest to cruciferous plants through all the southern region and may be expected to become a pest in all settled localities in the southwest portion of the country.

Chariesterus antennator Fab. Colorado.

Leptoglossus cinctus H. Shaf. (?) Colorado.

Anasa tristis DeGreer. Albuquerque, New Mexico. This familiar eastern pest is generally distributed over the southwestern country and will doubtless prove a pest in those regions. I have seen it in destructive numbers in central Kansas.

Alydus conspersus Montandon. New Hampshire; Iowa. This form has been confused with the European *calcaratus* from which Montandon has separated it under the above name and has stated its occurrence in Michigan; Burlington, Iowa; Massachusetts, Colorado and Dakota. It is generally smaller and lighter colored than *eurinus* Say, but specimens can be picked out of any large series which approach that species in size and markings and the two seem to me to be quite closely related, though I believe Montandon is correct in distinguishing them.

Alydus pluto Uhl. (?) This is a large black form, but if my specimens are good examples it might be considered an extreme form of *eurinus* larger and blacker than the average forms.

Scolopocerus secundarius Uhl. Colorado.

Jalysus spinosus Say. Albuquerque, New Mexico; San Diego, California; San Bernardino, California.

Nysius thymi. New Hampshire.

Nysius Angustatus Uhl. Colorado. This species is widely distributed and somewhat variable. It approaches *thymi* in northeastern part of the country and *californicus* of the southwest, and it seems to me to present a very close relationship to the *senicionis* of Europe.

Nysius californicus Stal. Seligman, Ariz.; Albuquerque, New Mexico.

Orsillacis producta. New Hampshire.

Ischnorhynchus didymus Zett. Colorado; Washington; New Hampshire.

Cymus angustatus Stal. New Hampshire.

Cymus claviculus. New Hampshire.

Oedancala dorsalis Say. New Hampshire.

Ligyrocoris sylvestris Linn. Colorado; New Hampshire.

Emblethis arenarius Linn. Barstow, Cal.; Peach Springs, Williams, Ariz.; Colorado.

Eremocoris ferus Say. Colorado.

Peliopelta abbreviata Uhl. Lawrence, Kans.; New Hampshire.

Melanocoryphus bicrucis Say. Colorado. It occurs very rarely at Ames, Iowa.

Melanocoryphus facetus Say. Winslow, Ariz.; Colorado.

Lygæus bistriangularis Say. Seligman, Winslow, Ariz.; Los Angeles, Cal.

Lygæus reclivatus Say. Barstow, San Bernardino, Cal.

Oncopeltus fasciatus Dallas. San Bernardino, Cal.

Largus cinctus H. Schf. Los Angeles, Cal.
Largus succinctus Linn. Colorado.
Trigonotylus ruficornis Fall. Colorado.
Resthenia insitiva Say. Colorado.
Resthenia confraterna Uhl. Colorado.
Resthenia insignis Say. Colorado.
Resthenia rubrovittata Stal. Colorado.
Oncerometopus nigriclavus Reut. Colorado.
Lopidea media Say. Colorado.
Lomatopleura Cæsar Reut. Colorado.
Hadronema militaris Uhl. Colorado.
Hadronema pulverulenta Uhl. Colorado.
Phytocoris colon Say. Colorado.
Neurocolpus nubilus Say. Colorado.
Compsocerocoris annulicornis Reut. New Hampshire.
Calocoris superbus. Colorado, New Mexico.
Oncognathus binotatus Fab. New Hampshire.
Poeciloscytus basalis Reut. Albuquerque, N. M.
Poecilocapsus lineatus Fab. New Hampshire.
Systratiotus americanus Reut. Colorado.
Camptobrochis nebulosus Uhl. Colorado.
Monalocoris filicis Linn. New Hampshire.
Labops hesperius Uhl. New Hampshire. Uhler refers this to the western states, but typical forms and also a short-winged form have been received from Dr. Weed.
Dicyphus californicus Stal. Colorado.
Orectoderus amoenus Uhl. Colorado.
Macrocoleus coagulatus Uhl. Colorado
Neoborus pettiti. New Hampshire.
Piesma cinerea Say. Colorado.
Corythuca arcuata Say. Colorado.
Aradus rectus Say. Colorado.
Aradus debilis Uhl. New Hampshire; Colorado.
Phymata wolfii Stal. Seligman, Ariz.; San Diego, Cal.
Coriscus inscriptus Kirby. New Hampshire.
Coriscus ferus Linn. Colorado.
Sinea diadema Fab. New Hampshire.
Sinea spinipes H. Schf. Albuquerque, N. M.
Sinea conspersa Uhl. Los Angeles, Cal.
Fitchia nigrovittata Stal. Colorado.
Diplodus luridus Santiago. Winslow, Ariz.
Apiomerus spissipes Say. Albuquerque, N. M.
Apiomerus flaviventris H. Schf. Albuquerque, N. M.
Apiomerus ventralis Say. Colorado.
Pelogonus americanus Uhl. Nebraska.
Galgulus oculatus Fab. Albuquerque, N. M.; Colorado.
Zaitha fluminea Say. Needles, Cal.
Serphus dilatatus Say. San Bernardino, Cal.
Notonecta undulata Say. Albuquerque, N. M.
Notonecta mexicana Am. et. Serv.; Peach Springs, Ariz.
Corisa harrisii Albuquerque, N. M.

LABORATORY NOTES IN ZOOLOGY.

HERBERT OSBORN.

It is my purpose, in these notes, to call attention to some matters of experience in laboratory work which may be of service to other teachers and also to place on record the results of some studies by students that appear to be worthy of preservation.

Laboratory work in zoology has been carried on at the Agricultural College since 1876, and for nearly all of that time under my own supervision, so that while my own specialty has kept me busy in other lines some notes from the experience of these years may be of service to teachers who may be situated in similar localities. It is needless to suggest that work in an inland laboratory will naturally take somewhat different lines than a seaside laboratory.

We first began the use of marine material in our laboratory about ten years ago and at that time there was but one place where material suitably prepared and at prices consistent with laboratory work could be secured. Now a number of seaside laboratories as well as individual collectors furnish excellent material and no laboratory need want in this direction. Hydroids, starfishes, sea urchins and squids seem most essential as representatives of groups unknown away from the sea-coast. The ease with which such material may now be had, the full treatment of these types in various guides and convenience of dissection may, however, almost be considered a danger as it may tend to the neglect of our common inland forms which it may, possibly, be a little more inconvenient to secure just at the time they are wanted. I believe we should be careful to avoid this danger, for students, especially those who may become teachers themselves, should be impressed with the fact that material for study is available at any point, and so far as they may be representatives of the groups to be studied, the species close at hand should be used.

The protozoans are of course available in every stagnant pool, but it is sometimes desirable to be sure of abundant supply of amoeba and other forms at a certain time, and this may be accomplished by keeping the contents of jars over from year to year, allowing them to dry up before winter or when not in use. For a number of years I kept a particular block of wood that furnished amœba regularly for a number of different classes. It was allowed to dry in autumn, the ooze with which it was coated of course remaining, and then two or three weeks before the material was wanted the jar in which it was kept was partly filled with water, and in due time an abundant crop of amœbæ could be secured.

The earthworm, clam and crayfish are of course standbys, and the only point I might suggest here is to have an abundant supply of these preserved, as it is sometimes difficult to secure these in abundance at just the time they are wanted. It is naturally demoralizing to a class to be short of material, and with classes numbering forty or fifty the question sometimes becomes a serious one. This is especially true in case the time for these subjects falls within a period of drouth when the earthworms may be out of reach except in favored spots, the crayfishes hidden in some very moist corner, or, with the clams, to be found only in some pool that has survived the drouth. Such material may be kept fresh in good sized tanks or aquaria, or preserved in alcohol; some at least should be prepared in the latter way for use in dissecting certain parts. I have a large cement lined tank sunk in the floor of the basement of the building occupied by the laboratory, which is very convenient for keeping clams, crayfishes, frogs and fishes, and it also forms an attractive feature, being as much sought for as the museum cases by visitors, especially by children.

I find in the vicinity of Ames that the common Differential Locust (*Melanoplus differentialis*) forms one of the most available species for laboratory work. It is much larger than the more common *femur-rubrum*, hence more easily studied by the beginner and is more easily collected in quantity than the large species of *Acridium*.

For fishes I generally find it most convenient to order through the meat market undrawn fishes of eight to twelve inches in length. Sometimes we get fresh mackerel or other marine fishes, but more commonly lake or river species.

Snakes and turtles have to be secured as they turn up, but students usually secure enough to answer the purpose. Turtles are not kept on the market with us, and to order them from a distance is rather expensive.

For birds, pigeons, or in case these are wanting, blackbirds or robins serve the purpose.

If classes are not too large the embryology of the chick forms a most entertaining and instructive study, but the work is somewhat difficult to manage except with students somewhat advanced, and even then it is best not to attempt to direct too many at once. The eggs may be incubated artificially, but about the most satisfactory way is to use a hen, especially if a good, persistent setter is available. Sometimes one can be kept busy for five or six weeks and in this time incubate a large number of eggs.

For small mammal the most available, easily secured and satisfactory with us is the striped ground squirrel (*Spermophilus tridecemlineatus*). These are very abundant on the campus, may be caught very quickly by the use of slipnoose cord and without any injury to any part of the body as occurs with rabbits if shot. This makes them available for injection or for any treatment desired. Rats I have seldom used, as with us it is more bother to secure them than squirrels, but of course rats, rabbits, cats and dogs are used on occasion. It seems to me fully as well to use a species different from the one described in the guide, if a guide is used, since it throws the student on his own resources, incites comparative study and prevents too close following of the guide, either in description or drawing, in fact the main object of the guide is to ensure attention to all structures that should be studied, and to avoid waste of material, in case the animal is

one not to be had in unlimited quantity. Also to secure careful dissecting and not mere cutting and slashing.

A "Study of the Brain of the Common Striped Squirrel," by Mr. T. J. Kerr of the class of 1890, yielded the following results that may be worthy of record, though it needs the drawings prepared in the study to fully exhibit the results.

The brain was studied especially in comparison with that of the rabbit as described by Parker (Zootomy, pp. 365–379).

The brain in general differs from that of *L. cuniculus* in being a little broader in proportion to its length. The olfactory lobes are smaller, shorter and more angular in outline. As the depressions on the ventral surface between the lobes of the cerebral hemispheres and the white bands connecting the olfactory lobes with the temporal are very shallow, the surface is smoother than that of *L. cuniculus*. The frontal and parietal lobes do not show on the ventral surface as much as they do in the rabbit.

The number of convolutions in each division of the cerebellum varies in different brains. The least number observed in the superior vermix was six, the greatest eleven, the average being about eight. The least number for each lateral lobe seven, the greatest fifteen, the average being about ten. For each flocculus the least number was four, the greatest eight, the average being about six. The vertical longitudinal sections present the usual tree-like appearance or arbor vitæ. The vertical transverse sections are less tree-like in appearance.

In *L. cuniculus* there is a slight elevation on which the pituitary body rests, but in *S. tridecemlineatus* there is a slight depression, a sort of nest.

The corpus callosum is a strong white transverse band connecting the cerebral hemispheres. It is about half as long as the cerebrum, instead of one-third as long, as in *L. cuniculus.*

The peduncles of the pineal body are thin white bands on the posterior two-thirds of the upper surface of the optic thalami, instead of one-half as in *L. cuniculus*. The two peduncles unite at the posterior boundary of the thalami and then pass backward and upward to the pineal body.

The optic lobes or corpora quadrigemina are two pair of rounded lobes lying just above the crura cerebri, just posterior to the optic thalami and third ventricle, just below the hippocampi majores and dorso-posterior part of the parietal lobes and just anterior to the cerebellum. The nates, the larger pair, lie almost entirely above the testes, instead of anterior to, as in *L. cuniculus*. As seen from behind after removing the cerebellum the testes are transversely elongated as in the rabbit.

The brain of the pocket gopher, studied by Mr. W. E. Harriman of the class of 1893, was compared particularly with that of the rabbit, as detailed by Parker (Zootomy, pp. 376-397), and with that of the striped gopher as given by Mr. Kerr in the paper previously quoted.

The brain of the pocket gopher (*Geomys bursarius*) is more nearly the shape of the brain of *L. cuniculus* than of *Spermophilus tridecemlineatus*, its width being less than is the same dimension in *S. tridecemlineatus*. However, it resembles the latter in point of there being comparatively smaller parietal lobes than in *L. cuniculus*. The dimensions, as averaged from measurements of thirteen brains, are as follows: Antero-posterior (from anterior end of olfactory lobe to posterior end of medulla) twenty-six milli-

meters. Lateral (through base of cerebral hemispheres) seventeen millimeters. Dorso-ventral (through median commisure), eleven millimeters, the largest 30x20x14 mm. The average weight of nine brains is three and five-tenths grams, the heaviest 3.922, lightest, 2.3012.

On the dorsal aspect of the pons at the end of the fourth ventricle is a curtain like affair at right angles to the longitudinal dimension of the ventricle called the valve of Vieussens. In *G. bursarius* this portion is very small. It appears to be attached to the anterior crura of the cerebellum. Anterior to this valve of Vieussens are two bodies, each deeply cleft or lobed into two hemispheres. They correspond to the Corpora quadrigemina of higher animals. The anterior body might be termed the tubercular nates, the posterior the tubercular testes. Still more anteriorally situated are two masses which are longer comparatively in *G. bursarius* than in either *S. tridecemlineatus*, or *L. cuniculus*. They are the Thalami optici. * * *

The cerebellum is rather spheroidal in shape, and in mass compares with the cerebrum as about one to four. In the higher animals this portion of the encephalon is divided into two distinct hemispheres, each hemisphere being in turn cleft into several lobes. But in *G. bursarius* it is more accurate to consider it as composed of three distinct lobes, called respectively, the central lobe and the two lateral lobes. Just lateral to these parts, on either side, is a peculiar body coiled upon itself, somewhat like a snail shell, called the Flocculus. * * *

The surface shows a sort of convolution being traversed in a general transverse direction by numerous curved furrows or sulci, which vary in depth in different parts. In this respect the cerebellum is quite similar to that of higher forms, which is also true of its structure and the arrangement of the gray and white matter which on cross section shows the characteristic arbor vitæ appearance.

On the ventral surface of the cerebrum, extending well forward from about the center of each hemisphere, are the olfactory lobes; they protrude about two to four millimeters beyond the frontal lobes.

The eighth pair, or auditory nerves, are large comparatively, and originate in a groove between the olivary body and restiform bodies at the posterior border of the pons.

The earthworms of the State were studied by Miss Vinnie Williams of class of 1893, with the result of finding, according to her determination, two distinct species in the State.

These were the *Allolobophora turgida*, specimens of which were secured from Tama county, and the *Lumbricus rubellus*, species of which were obtained from Chickasaw and Poweshiek counties.

Doubtless other species occur, but apparently no one has hitherto recorded any determinations. The species most common at Ames is probably the *Allolobophora turgida*, but with ordinary preparation the positive separation of species is difficult and few have been examined when prepared so as to permit rigid examination.

ADDITIONS TO THE KNOWN SPECIES OF IOWA ICHNEUMONIDÆ.

BY ALICE M. BEACH, AMES, IOWA.

The list herewith presented embraces those species taken in Iowa which are not recorded in the Catalogue of Iowa Animals, prepared by Prof. Herbert Osborn and published in 1892:

Ichneumon galenus Cress.
Ichneumon pulcher Brulle.
Ichneumon otiosus Say.
Ichneumon pervagus Cress.
Ichneumon vittifrons Cress.
Ichneumon sp. undetermined.
Ichneumon vinnulus Cress.
Ichneumon longulus Cress.
Amblyteles indistinctus ? Prov.
Amblyteles subrufus Cress.
Herpestomus sp. two, undetermined.
Centeterus tuberculifrons ? Prov.
Phygadeuon subfuscus Cress.
Phygadeuon sp. three, undetermined.
Cryptus sp. undetermined.
Cryptus contiguus Cress.
Joppidium sp. undetermined.
Linoceras sp.
Hemiteles sp. five, undetermined.
Nematopodius sp.
Pezomachus sp.
Nototrachys four, undetermined sp.
Exochilum sp.
Heteropelma two sp., undetermined.
Heteropelma datanæ Cress.
Anomalon sp.
Anomalon ambiguum ? Norton.
Anomalon semirufum Norton.
Campoplex diversus Norton.
Limneria five, undetermined sp.
Cremastus two, undetermined sp.
Angitia six, undetermined sp.
Thersilochus sp.
Exetastes sp.

Mesoleptus sp.
Tryphon four, undetermined sp.
Polyblastes sp.
Bassus two, undetermined sp.
Bassus sychophanta Walsh.
Coleocentrus sp.
Ephialtes sp.
Theronia sp.
Pimpla tenuicornis Cress.
Pimpla inquisitor Say.
Polysphincta sp.
Glypta tuberculifrons Cress.
Glypta rufiscutellaris Cress.
Arenetra ventralis Cress.
Lampronota rufipes Cress.
Xylonomus stigmapterus Say.
Xylonomus albopictus Cress.

A NEW SPECIES OF PEMPHIGUS OCCURRING ON THORN.

BY F. ATWOOD SIRRINE.

Œstlund[1], in describing the characters and work of *Aphis crataegifoliæ* Fitch, says: "Found on leaves of *Crataegus* corrugating them. Specimens taken during May on *Crataegus tomentosa* Linn, were found to curl the leaves very much, and as they turned dark brown or red they became very conspicuous."

The past season what was taken to be the fundatrix of a *Schizoneura*, possibly *crataegi*, was found May 23d corrugating the leaves of *Crataegus tomentosa* (?) and at the same time causing them to turn a bright red or scarlet color. The fondatrici of what was supposed to be *Aphis crataegifoliae* were found at the same time and on the same plants, curling the leaves but not to such an extent as the supposed *Schizoneura*, nor did they cause the leaves to change color.

Later in the season as *Aphis crataegifoliae* increased in numbers they were found in the colored corrugated leaves with the *Schizoneura?* On June 26th winged specimens of the latter were obtained. The venation of the wings proved that they were *Pemphigus* and not *Schizoneura*. By the 10th of July these had all left the Hawthorn. On October 7th, dead, shriveled specimens of *Pemphigus* were found under the rough bark of Hawthorn (*Crataegus tomentosa* Linn.) which agreed in venation with the form taken in the curled leaves in the spring; an oviparous female was also taken, though the latter may have been an oviparous female of *Schizoneura*, as both

[1]Synop. Aphididae of Minn. (Bull. No. 4, Geol. and Nat. Hist. Surv. Minn. p. 51.)

the *Schizoneura* and *Pemphigus* females are known to occur under the rough bark of trees. To the naked eye the form taken in June resemble the color of the corrugated leaves, while older specimens of the fundatrici, being covered with a pulverulent secretion, aside from the flocculent secretion near cauda and sides of the body, are of a bluish purple.

Though this may prove to be the spring migrant of a form already described, and named, as occurring on some other plant, it does not agree with any description of *Pemphigus* to which I have access, moreover no *Pemphigus* has been described as occurring on Hawthorn. Hence the specific name of *corrugatans* from its habit of corrugating the leaves on which it feeds, is proposed for the present, or until its complete life cycle shows it to be one stage of a known species. The following descriptions of the fundatrix, pupa and alate migrant are appended:

Pemphigus corrugatans, n. sp.

Alate Vivip. form, Spring Migrant, from corrugated colored leaves of *Crataegus tomentosa (?)*, June 26th, 1893.

Expanse of wings, 6.52 mm.; length of body, 2.35 mm.; width, 1.10 mm.; length of antennæ, 0.85 mm.; (Joint I., .05 mm.; II., .07 mm.; III, .30 mm.; IV., .13 mm.; V., .17 mm.; VI. plus unguis, .16 mm.); Joint III, with about fifteen transverse sensoria. In some cases part of these are double, making upward of twenty-five in all; IV., with from six to twelve; V., with from three to five; VI., slightly roughened. (These sensoria are situated on raised portions of chitine, so they appear as transverse ridges, but not as complete chitinous rings in any case). Rostrum reaching second pair of coxae. Distance between base of first and second discoidals varies from 0 to .08 mm., in some cases the second discoidal is united with the first for a distance of .20 mm. Distance between base of cubital and second discoidal varies from .05 mm. to .10 mm.; the former subobsolete at base. Stigmal with a simple curve. Distance between apices of all the veins approximately equal; (the apices of the stigmal and cubital may average a trifle nearer than the others). Stigma, .59 mm. by .16 mm., rhomboidal. Distance between discoidals of the posterior wings approximately the same as in anterior pair; costal abruptly curved forward where the discoidals issue.

Color.—(Specimens not mounted, observed with hand lense) antennæ, head and wing callosities black; thorax, yellowish green; eyes, brown; legs, dusky. The two median and the lateral lines of dermal wax glands* secrete the longest flocculent material, so there is a ridge of the latter between the wings, and a margin of the same at the sides of the body. These masses of waxy secretion crowd the wings into an oblique position. (The variation in the length of the secretion from the dermal glands is true for the pupa, and larval fundatrix; those on the latero-caudal portion of the abdomen secreting the longest flocculent material so the body appears flattened.)

(Specimens mounted in balsam and examined with compound microscope) ground color yellowish green, apex of abdomen a shade lighter; wing callosites dusky to black, antennæ and head somewhat darker; pro-

* On the abdomen there is a dermal gland on each segment between the median pair and the one on the lateral margin. As far as observed in *pemphigus* there are a pair of these glands on the head, two pairs to each thoracic segment, a median pair and one on each lateral margin; three pairs to each abdominal segment, median, submedian and lateral. Those on the abdomen are united in some instances, especially toward the cauda.

thorax with a narrow black line on the anterior dorsal margin; eyes brick red; legs dusky; wing insertions yellow, apex of beak dusky, remainder, unicolorus with body. Cauda distinct. The median dorsal glands larger than either the lateral or the submedian.

Pupa—Length of body, 3:09 mm.; width. 1.39 mm.; length of antennæ, .83 mm ; separation between joints, III and IV, not distinct; sensoria, not distinct. Cauda, distinct, .22 mm. long. Rostrum reaches second coxæ, sometimes beyond.

Color—(Unmounted, examined with band lense.) Yellowish green; wing pads, whitish. (Mounted, examined with compound microscope.) Whole body light green with a yellow tinge, sometimes yellowish white, depending on age after moulting; antennæ, wing pads and legs whitish; eyes, brick red. The last abdominal segments are crescent shaped, producing an indenture each side of the cauda.

Fundatrix—Length of body, 3.66 mm.; width, 2.74 mm.; length of antennæ, .87 mm. (Joint I, .087 mm.; II, .12 mm.; III, .24 mm.; IV, .14 mm.; V, .14 mm.; VI with unguis, .15 mm.); separation between III and IV not distinct in immature forms. Beak, barely reaching second coxæ.

Color—(To naked eye) Greenish purple; (mounted, examined with compound microscope) olive green with a yellow tinge.

HACKBERRY PSYLLIDÆ FOUND AT AMES, IOWA.

BY CHAS. W. MALLY.

The insects now under consideration belong to the family *Psyllidae;* sub-family *Psyllinae;* and the genus *Pachypsylla.* The genus, according to Dr. C. V. Riley, "has no equivalent in the European fauna; but some allied, still undescribed, genera occur in the New World."

The species which first attracted attention was *Pachypsylla celtidis-mamma.* Some observations were recorded during the autumn of 1891, but no regular observations were made till March, 1892. At this time the weather was cold, and the adult insects were hidden away in the cracks and creases of the hackberry bark. It was difficult to find them at first, because their general color closely resembles that of the bark. Large numbers of the adults were found on the sticks and pieces of bark that were lying around under the trees. The old hackberry leaves were examined with special reference to the galls that remained over winter, and in no case was a gall found that contained a living larva, proving that in this case, at least, they had issued from the gall in the fall and transformed to the adult stage. Some difficulty was experienced in finding the old leaves as they had probably been carried away by the wind. If any of the larvæ fail to issue in the autumn, the evidence seems to prove that they perish in the galls.

The chief hiding-place of the adults is in the rough sheltering bark of the

trunks of trees. Toward the top of the tree the bark is younger, less roughened, and therefore furnishes less protection for the insect. Consequently, very few of the adults are found in the top of the tree and out toward the end of the branches.

During the latter part of March, as the days grew warmer, the adults became active, but moved about very little. During the afternoon of April 7th, which was warm and pleasant, they were out toward the ends of the limbs; but as night came on most of them went back to the trunk of the tree, only a few remaining on the slight excrescences of the bark, in the angle between two twigs, or at the base of a large bud. They could be removed from the last named places by simply shaking the limbs. Hence, if they settled down for the winter on the twigs, the many fierce winds would soon sweep them off and carry them to destruction.

About April 30th the buds of the trees began to swell and open out for the year's growth. The Psyllidæ now begin to migrate to the buds and probably feed on the juices of the young tissue.

The first eggs were found on the young leaves May 5th. After this time the adult females could be found depositing eggs in the opening buds and on the underside of the expanded leaves. In the opening buds, where the leaf veins are small and close together, they tend to deposit the eggs in rows between the veins; but as the leaves expand to their full size, they are deposited at random and in large numbers.

Adult females of different species are often found depositing eggs on the same leaf. Hence the larvæ, and later on the galls of all the species are found on one leaf. The time of first egg deposition depends largely on the season and the location of the tree. If, for example, a tree is located in a warm, sheltered place, the adults become active, the young leaves put forth and consequently the eggs will be deposited earlier. If the tree is in a cold, exposed place, the development of both tree and insect is retarded. More time is required for the eggs to develop on exposed trees than on those more favorably located. This indicates that a low temperature retards the development of the embryo. In general the eggs seem to develop best at the temperature most favorable to the healthy growth of the leaves. During the month of May eggs are continually deposited. May 27 a number of eggs on one tree were compared, and judging by their general appearance, some were recently deposited, while others were quite well developed. On a tree very favorably located a number of the young larvæ were found on the upper surface of the leaf. After searching sometime for larvæ, a leaf was found bearing a small gall already closed around the insect. On the upper side of the leaf this gall was but slightly raised, having a small cone-shaped projection. On the under side the gall was roundish and covered with a white frosty pubescence. Careful dissection of the gall revealed a young larva which proved to be identical with those on the surface of the leaf.

From the above stated facts we learn that there is a great variation in the hatching of the larvæ. This variation continues throughout the larval stage and greatly augments the difficulty of working out the successive stages in their development.

From May 27 to June 22 the larvæ appeared in great numbers and many galls were starting. From this time till August 16 larvæ developed quite slowly. The galls, however, developed quite rapidly and in a short time

the species could be distinguished. Many of the galls contained more than one larva. Some of the typical *P. c. mamma* galls were two-celled. Others had a large cell in the normal position, and three or four smaller ones located just above the normal one and around the cup-like depression. In one or two cases five were found, six being the highest number ever found in one gall.

After the latter part of August the changes in the larva were more rapid the abdominal spines are more rapidly developed, and a short time before changing to the adult stage the larva produces a white cottony substance which is quite abundant on the posterior portion of the abdomen. They also undergo one moult a short time before sawing through the gall. This is quite certain, for cast skins have been found with the larvæ.

THE EGGS.

The eggs are oblong-oval, being widest at the middle, where they measure about .15 mm. Their greatest length is about .3 mm. They are broadly rounded at one end, but taper more strongly at the other, thus giving the eggs a pointed appearance. When deposited on the leaf they have a white, glistening appearance. The first eggs were found May 5th, and the first larvæ May 27th. Judging from this, in a general way, it is safe to say that the eggs hatch in about twenty to twenty-two days.

The Larvæ.—Soon after hatching the young larvæ measure about .15 mm. in length and about the same in greatest width. The head and the divisions of the thorax can be but faintly recognized. The abdomen is drawn cephalad, so that only the first segment is visible for its full width, and only the tip of the seventh and the small eighth or anal segment. The antennæ are invisible at first; tarsi, two-jointed, but very indistinct; claws represented by two very small bladder-like bodies. As the larva grows older, the antennæ make their appearance, at first showing but four joints. The compound eyes soon become larger, and the abdomen develops so that five of the segments are visible. The posterior end of the body now presents a lobed appearance, because the last three segments are very small, and drawn cephalad, pushing the central portion of the first five segments forward, while the sides extend backward, forming a lateral lobe on each side. The lines separating the abdominal segments are most clearly seen on the dorsal surface. In some cases they do not reach the sides as closely defined lines, but seem to terminate in little circular, transparent spots, probably representing the division between the tergum and the pleurum.

From June 1st to June 22d, no very marked changes, except in size, take place. The last three abdominal segments are very slow to develop.

The larvæ examined August 16th showed some important changes. The antennæ increased in comparative length, having from six to ten joints. The compound eyes more prominent, mouth-parts larger, and the different divisions quite distinct; legs much larger, more prominent and furnished with numerous hairs. The two joints of the tarsi are quite inconspicuous, the strong curved claws apparently being attached to the distal end of the tibia rather than the tarsus. The two pairs of wings have begun to develop and appear as small transparent pads arising from the mesothorax and the metathorax respectively, and are immovable. The divisions of the sternum are quite distinct, and the coxæ much more prominent. The abdominal segments are all closely defined; the last three, however, are quite closely

united and are more chitinous. The fleshy anal process of the young larva is represented by a chitinous oval spine. On either side of the base of this oval spine can be seen a small tubercle which may represent some of the developing abdominal teeth. Each segment is provided with conspicuous hairs which are shortest at the division of the segment.

Segments seven and eight contain a tube extending longitudinally, and sends out two small, round branches in the seventh segment and terminates in two short curved branches which extend nearly to the tip of the notched oval process. This tube cannot be traced beyond the seventh segment, and probably represents the developing genital organs.

LARVA AND PUPA.

The full grown larva and pupa are described as follows:

Color, in general, bluish green; antennæ and legs more yellowish; "broadly oval in outline; widest at the middle of the abdomen;" head distinctly separated from the pronotum; "including the eyes it is as wide as the mesonotum at middle;" front margin broadly rounded; but not lobed as in the adult, and furnished with numerous hairs. Frontal cones, obsolete; eyes are of a black color, large, reaching the posterior margin of the head, and have a granular appearance. The antennæ differ from the adult form in being thicker and therefore appear to be somewhat shorter. The lateral hairs are more conspicuous. No essential difference in the mouth-parts.

The anterior pair of legs thicker than in the imago; tarsus about the same width as the tibia, and the articulations not so marked as in the adult, thus giving the tibia and tarsus a more blended appearance. The second pair of legs virtually the same as the first, but the third pair has been developed so that in the adult they will be fitted for leaping.

The mesonotum presents three main divisions, as in the adult, but not so clearly defined.

The metanotum is moderately distinct, having the two divisions but faintly marked, and joins the first abdominal segment by a wavy line.

The wing-pads are smooth, shining, and diverge posteriorly, not quite attaining the apex of the second abdominal segment. The anterior ones are larger and wider than the posterior ones, but the latter project internally and posteriorly. During the development of the larva the venation and folding of the wings cannot be seen, but when about to transform the venation and folding are usually quite distinct.

The abdomen is composed of eight segments, is widest at the middle; tapers gradually at the base, but strongly at the top. The first segment is quite short, as wide as the metanotum, and the dorsal surface is ornamented with numerous reddish lines passing obliquely outward and forward from the central portion.

The second segment is nearly twice as long as the first and distinctly separated from it. The third is a little longer and wider than the second, the fourth being widest of all, but about equal in length with the fifth. The last three segments are rather indistinctly separated, much shorter, moreover, and beginning at the latter half of the sixth are more chitinous than the preceding ones. The lateral part of the first five segments especially are separated by slight constrictions, giving them a bulged appearance. The sides of the abdomen are furnished with hairs, which are larger and more numerous on the central portion of each segment, growing smaller

and less numerous toward the joint. They are longest on the posterior part of the abdomen, but do not form a fringe. The eighth segment is drawn out into a horny anal process. The last three segments are usually provided with a number of backwardly-directed teeth, which Dr. C. V. Riley has described as follows:

"Sixth joint at middle of hind margin with two or three very small teeth placed transversely, and with no lateral teeth; seventh joint at middle of hind margin with a tranverse row of four teeth, and on each side with two or three (often obsolete) teeth or tubercles; anal joint with the horny process about half as long as the joint and pointed at tip, while at the base of the process, on each side, a lateral row of four small closely placed teeth extends to the underside, and finally on the disk of the joint three teeth, triangularly placed, the posterior being the largest; behind this group, and just above the base of the process, is another tooth, nicked at the tip."

In many specimens the teeth of the sixth segment were simply indicated by a more chitinous texture than the surrounding tissue. In others these teeth are represented by very slight tubercles, while in still others, they were larger, but indistinctly separated.

By examining a large number of specimens it was found that the teeth of the seventh segment were subject to considerable variation. Usually there were three placed transversely. In some there appeared to be four teeth represented, the central one being the largest and most posterior, having a small tooth on one side of its base, and two small ones on the other. In still others there seemed to be five teeth represented. The large one same as before and then two small ones at the base on either side. In the latter case the four basal spines were placed in a gentle curve around the larger tooth.

Is there any way of accounting for the variation in this group of teeth?

In one specimen having four teeth, one of the two basal ones seemed to be very deeply nicked, while the other was not. In the case where five teeth were present we could consider that both of the small basal teeth were very deeply nicked, even to such an extent that the two parts became separated, thus presenting the appearance of four distinct teeth. The first lateral teeth occur on the seventh segment. From a dorsal view some specimens present only one lateral tooth, but further examination reveals two or three. In one case five lateral teeth were found, the central ones being the larger. No important variations were found in the anal segments, although one of the four small teeth on either side of the anal process was difficult to find.

One very attractive feature of the color of the larva is the blending of the bluish-green parts and the rosaceous markings of the abdominal segment.

TRANSFORMATION OF PUPA TO ADULT.

When exposed to the air for a short time the pupa changes to a slightly paler color. Soon the longitudinal muscles of the abdomen begin to contract and draw it forward in the surrounding pupa skin, and thus allowing it gradually to assume its natural position. In this process the displaced portions of the abdomen catch in front of the depressed divisions of the segments, and by tending to assume their former position uses them as points of support from which to force the body forward.

At the same time, irregular movements of the legs and antennae take place. Soon the pupa skin splits on the dorsal side of the head and thorax, and by the longitudinal contractions of the muscles the dorsulum is first forced out, then the head and antennae, the legs, and finally the abdomen is slowly withdrawn and the pupa skin remains attached by the claws.

At first the adults are of a light yellowish green, but soon change to a darker color. Some specimens seem to have great difficulty in starting the tip of the abdomen, it apparently being held by the anal spines.

THE GALLS.

The galls are subject to great variations. The typical gall of *P. c. mamma* has been described by Dr. C. V. Riley as follows: "This gall on the upper side of the leaf is represented by a cup-shaped impression measuring on an average 4.5 mm. across, with the outer rim always regularly circular, and not, or but slightly, elevated above the surface of the leaf; at the bottom of the cup a small medium nipple (often obsolete); walls of the impression greenish, the bottom more yellowish. On the under side of the leaf it is much larger than any of the other leaf galls, conical, either slightly narrowing apically, or, more frequently, slightly enlarged. The sides are vertical or nearly so; the top broadly rounded without medium depression or central nipple, size very variable, averaging in height 6.7 mm. and in diameter at base 4.5 mm. Color, pale greenish yellow, with the tip more brownish; surface opaque, rugosely reticulate; at the base often covered with a whitish pruinescence, rarely with a few scattered hairs at the tip. The walls of the gall are hard and woody, at bottom averaging 1.75 mm., and at roof 0.75 mm. in thickness. The cell is large, and in cross-section much more crescent-shaped than in the preceding species."

The above description is for the typical form for *P. c.-mamma.* But when the galls are compared we find that the shape and size of the gall is not at all constant. Besides those that are enlarged and rounded at tip, we find a great many that taper gradually to the apex which in some is slightly rounded, in others almost truncate, and in still others slightly depressed. Some have the basal half large and rounded, but at middle it contracts rather abruptly and tapers more strongly to the top which is rounded. In another variation the basal half and the apical half are both rounded and subequal, but separated by an acute circular constriction at the middle. In another form the sides of the gall begin to curve outward just as they rise from the leaf, giving the gall a general circular outline.

By collecting a large number of the galls and placing them singly in little pill-boxes, the adults that issued from each gall could be noted. It was found that *P. c-mamma* occurred in all the different variations, thus showing that these variations are not of specific importance.

Besides the typical form of *P. c.-mamma,* a number of variations were found in the galls just mentioned, but as they present such a great number of variations, and no constant characters being found as yet, no attempt will be made to describe these varieties.

DISSEMINATION.

Mention was made of the fact that it was difficult to find the old leaves in sufficient numbers to be of any great value for observation, as they had been carried away by the winds. This is one of the means provided for

the dissemination of these insects. In the autumn of 1891 many of the leaves fell to the ground and were carried away by the winds before the larvæ could issue. Many trees are located on the banks of streams into which the leaves may fall, and in case the larvæ has not begun to issue so that the water cannot enter the gall, they may be carried many miles down stream and cast ashore; then the larvæ issue, transform to the adult stage, migrate to the proper host and are in condition to multiply during the following season. In a number of cases the adults have been found in places quite distant from any hackberry trees. At first thought it might be held that a strong wind caught them while on the wing and carried them away. But this is doubtful, since they may have come from leaves that were carried away.

NATURAL ENEMIES.

A number of parasitized larvæ were taken about September 1. At different times small white larvæ were found in the cell with and devouring the Psyllid larva. Upon further examination it was found that the cause for some of the Psyllid larvæ changing to such a brown color and having such a dry, shriveled appearance was that the egg for this white footless larva had been deposited within the Psyllid larva; others were probably deposited outside the Psyllid larva, and so fed externally.

This parasite belongs to the family Chalcididæ in the order Hymenoptera, and attacks all the species found at Ames, Iowa.

Specimens of the Psyllidæ were sent to Dr. C. V. Riley, U. S. Entomologist, Washington, D. C., for determination and the following species were named:

Pachypsylla celtidis-mamma.
Pachypsylla celtidis-minuta.
Pachypsylla celtidis-asteriscus.

Since then specimens of *Pachypsylla celtidis-gemma* have been found, and also a new species that infests the twig of the hackberry, As far as I know, no mention has been made of it, and so liberty will be taken to give the most prominent characters, *i. e.*, those used in determining the species as shown in the table below.

The following is a table prepared by Dr. C. V. Riley for the classification of the three most common species of the genus Pachypsylla.

Perhaps many members of the Academy do not have access to this table, and therefore I take liberty to insert it in this article and also add the characters for separating the species which infest the twig of the hackberry.

"Head and dorsum opaque; front wings submembranaceous or subligatine, not rugose; pterostigma. distinct; both marginal cells very long, narrow, and of about equal size and length; anal style of full-grown larva and pupa long.

Dorsulum and mesonotum alutaceous, glabrous; front wings narrowly rounded at tip, widest in basal half; genital segment of female longer than the rest of the abdomen; anal style of full grown and pupa notched at top................*venusta.*

Dorsulum and mesonotum rugoso-punctate, with distinct but very short, sparse pubescence; front wings broadly rounded at tip, widest in terminal half; genital segment of female shorter than the rest of the abdomen; anal style of full-grown larva and pupa pointed at tip.. ...*c.-mamma.*

Head and dorsum shining, without pubescence; front wings somewhat convex, basal half not wider than terminal half, broadly rounded at tip, distinctly rugose.

Pterostigma indistinct; marginal cells less narrow, the first shorter and somewhat smaller than the second: genital segment of female shorter than the rest of the body; anal style of full-grown larva and pupa very short, nicked at tip..*c.-gemma.*"

Pterostigma distinct black, marginal cells less narrow, the first being shorter and more nearly V-shaped than the second; head and thorax black, marked with yellow; antennæ black; wings with a smoky band along the anal and apical margins, and extending along the branching of the veins toward the base. Full-grown larva and pupa larger than the preceding one, anal style moderately long and notched at tip. (Galls oblong-oval, and are located in the twig or base of the larger limbs, just beneath the bark)................................*c.-inteneris*, n. sp.

AUTHOR'S INDEX—VOLUME I.

(PARTS I–IV).

SUBJECT INDEX—VOLUME I.

(PARTS I TO IV.)

A.

B.

C.

D.

E.

F.